DOCUMENT RESUME

ED 447 687 EF 005 816

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TITLE A Synthesis of Studies Pertaining to Facilities, Student Achievement, and Student Behavior.
PUB DATE 1997-05-00
NOTE 207p.; Ph.D. Dissertation, Virginia Polytechnic Institute and State University.
PUB TYPE Dissertations/Theses - Doctoral Dissertations (041)
EDRS PRICE EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Academic Achievement; *Educational Facilities; Educational Research; Elementary Secondary Education; Public Schools; *Student Behavior; *Student School Relationship

ABSTRACT

This study examines the research on the extent school facilities influence student achievement and behavior. Fifty-three studies conducted since 1980 were synthesized that included the independent variables of noise, facility age, color, lighting, maintenance, density, climate conditions, and classroom structure. Data suggest that all the independent variables have an affect on student achievement and behavior. Additionally, the literature indicates that student attitudes and behaviors improved when the facility improves or is congruous with the facility needs for the instructional program. The study also discusses the theoretical model developed by Cash (1993) that explains the relationship between the condition of the school and student achievement and behavior. Using this model as a reference, implications for practice that need to be considered by educators and researchers are discussed, including leadership; funding needs; maintenance; and the attitudes of parents, faculty, and students. Appendices list the descriptors used in the database search, the review of research form, the measurement of dependent variables, and notes for educators and architects. (Contains 82 references.) (GR)

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ED 447 687

A SYNTHESIS OF STUDIES PERTAINING TO FACILITIES, STUDENT ACHIEVEMENT, AND STUDENT BEHAVIOR

by

Linda Kay Lemasters

Dissertation submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

in

Educational Administration

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May, 1997
Blacksburg, Virginia

Key Words: Facilities, Achievement, Behavior

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A SYNTHESIS OF STUDIES PERTAINING TO FACILITIES, STUDENT ACHIEVEMENT, AND STUDENT BEHAVIOR

by

Linda Kay Lemasters

Committee Chairman:

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(ABSTRACT)

This study is a synthesis of the research since 1980 pertaining to the relationships between school facilities and student achievement and school facilities and student behavior. A matrix was developed relevant to the research. This matrix was used to identify not only the researchers and the areas in which the research was conducted, but also the areas in which there was no available research. The former is important to the educator and school designer; the latter is essential for future researchers.

Fifty-three studies were synthesized that included the independent variables of noise, facility age, color, lighting, maintenance, density, climate conditions, and classroom structure. From the research reviewed, educators and designers should consider the impact of building condition, lighting, and site noise when planning, remodeling, designing, or maintaining schools, as there was conclusive evidence that the effects of these three variables on student achievement and behavior were significant. Although not conclusive, data from

the studies indicated that all of the independent variables affected the dependent variables of student achievement and behavior.

These findings, along with the findings from syntheses completed in 1979 and 1982, indicate that building condition is directly related to student achievement and behavior. The literature supported that the resultant attitudes and behaviors of students improved when the facility improved or was congruous with the facility needs for the instructional program.

A theoretical model was discussed that was developed by Cash (1993) and substantiated in the research of Earthman (1995), Hines (1996), and this synthesis. Using the model and the knowledge base developed by this and previous syntheses enables designers to build facilities with research-based designs and gives impetus to educators to strive to maintain facilities at the highest level possible. Even when the variance of the building environment was minimal, it was a portion of the elements affecting behavior and achievement that could be controlled through the efforts of educators and design professionals. In addition, it is a very visible demonstration or value statement made to the student of the importance that society or the community places on education.

DEDICATION

This study is dedicated to my parents and my husband. My parents are a part of any accomplishment, as they planted the seeds for my dreams. My husband would never allow me to say "quit."

ACKNOWLEDGMENTS

I am indebted to several people and organizations for creating opportunities and assisting me in the pursuit of this degree. It was my extremely good fortune to have Dr. Glen Earthman as a guide and mentor during my coursework, research, and writing process. His expertise in the discipline, his nurturing manner, his expectations for the document and my future contribution to the literature have been an inspiration.

Dr. Robert Richards was influential in my getting into the program, and, at one time, encouraging me to complete the coursework. His positive attitudes are a supporting factor to all students from the tidewater area.

Dr. David Parks played an important role in assisting with the organization of the research. More important, however, is the inspiration that he shared during his class lectures and during the writing process.

I want to express my appreciation to Dr. Richard Salmon, Dr. Carol Cash, and Mr. David Boddy for serving on my committee. Dr. Cash's expertise in the area of facilities made a significant impact on my dissertation. Mr. Boddy's experience with the Virginia Department of Education and as an architect was most helpful.

This expression of my appreciation would not be complete without mentioning the support of the Gloucester County School Board, my administrative team members, Patricia Hogge, and Mary Alice Livingston. The

school division did not simply allow me to pursue this degree, but they wanted me to be successful in this pursuit.

A very special mention is reserved for Roger, Scott, and Merrideth Lemasters. They permitted me to neglect my role as wife, mother, and friend while I pursued this goal. They served as a perpetual source of encouragement and inspiration.

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CHAPTER 1

INTRODUCTION

As the place where children learn has gone from the one-room school building to large, beautifully designed structures, research has been conducted on nearly every component of the physical environment of the student. Some of the studies have concluded that there is a positive relationship between the facility and student achievement and behavior; just as many studies in the past have shown little or no relationship of the facility to achievement and behavior.

Research on facilities and student achievement, performance, and attitudes was reviewed by Weinstein in 1979 and McGuffey in 1982. Although these researchers provided syntheses of 232 studies (Earthman, 1996), they found it difficult to provide a prescription to make the physical learning environment more productive.

During the nineties, educational professionals, community members, engineers, architects, students, and other interested professionals often have engaged in a collaborative process to design schools, but little reference is made during this process to the available research findings or what provides the most efficient atmosphere for learning. Buildings are planned and designed without the assistance of research data that give insight into the best practices in the field of design and construction (Agron, 1994). This does not mean that the

most recent research was not available, but rather that it has not been easily accessible or widely publicized for the practitioner.

There have been many studies completed since Weinstein's and McGuffey's reviews in 1979 and 1982, but there has been no critical review of this research during the past fourteen years. Such a synthesis of the literature was needed to ascertain the most recent conclusions drawn by researchers and to make this information known and accessible to planners and designers of facilities.

Purpose

The purpose of this study was to review and synthesize systematically the research findings from the various studies pertaining to the relationships between school facilities and student achievement and student behavior. A matrix of the research was developed that identified the researchers, as well as the variables in their respective studies.

Significance

The following indicated a need for the synthesis of research on facilities and how this research affects achievement and behavior:

1. There has not been a synthesis of the research since the early 1980's (McGuffey, 1982; Weinstein, 1979). Thus, educators and architects do not have a review of recent research that is accessible.

2. Many facility planners and designers have expressed a high degree of interest in this area of research, but they have not had the time or opportunity to perform such research (Earthman, 1996).

3. Until there has been a compilation of the research in the field, future researchers would not know the areas in which further research was needed.

4. The Executive Director of the Council of Educational Facility Planners, International, expressed a need for this organization to investigate what the research says about facilities and how they influence both student achievement and behavior.

5. During the 1996 legislative session, the Virginia House of Delegates and Senate passed Joint Resolution (HJR) 135 to establish the Commission on Educational Infrastructure. This report may provide a source of information to this Commission.

Scope of the Study

1. Studies synthesized in this research were those completed since 1980 that have dealt with the relationships between educational facilities and student achievement and behavior.

2. A meta-matrix (Table 3, p. 204) was developed of the research that has been completed since 1980 relevant to this review (Miles & Huberman, 1984). The matrix not only has identified the researchers and the areas in which research has been conducted, but also has identified the areas in which there was not available research.

Limitations

1. This research did not address the total area of facility planning, design, and finance. The matrix and synthesis of research were limited to studies of the relationship between the built environment and student achievement and student behavior.

2. In the search for research, it was possible that all available studies were not identified. However, an attempt was made to identify all significant education studies.

Methodology

White (1994) stated that the goal of research synthesis is not to track down every related paper but "to avoid missing a useful paper that lies outside one's regular purview" (p. 44). Therefore, studies were identified by using several generally accepted sources.

1. An ERIC search was conducted along with searching the data base Educational Abstracts. These searches, as well as searches in other data bases, were done using a very comprehensive list of descriptors (Appendix A).

2. The Avery Index to Architectural Periodicals was searched. This data base provided an international search of the literature.

3. References in review papers, books, and nonreview papers were traced.

4. A search was made for unpublished studies by using the data base Dissertation Abstracts.

5. Colleagues, noted scholars, and experts in the field were interviewed for potential sources of studies.

In the process of identifying significant studies, every attempt was made to acquire copies of the primary documents.

It should be acknowledged that there was a discretionary element in the selection of the studies. As this document was expected to be useful to educators and architects, the synthesis was compiled with emphasis toward that readership (White, 1994).

After the studies had been selected, each was critically reviewed and the following components were documented:

1. Name(s) of researcher(s),
2. Title of the document,
3. Statement of the problem,
4. Hypothesis(es),
5. Methodology,
6. Population in the study,
7. Variables addressed in the study, and
8. Findings.

A form was used (Appendix B) to keep the above elements of the data collection process uniform.

The reviews were organized by stacking clusters of variables, keeping like variables together. Table 1 summarizes the number of studies that were found by independent and dependent variable.

After the reviews were stacked, Chapter 2 was begun by synthesizing the studies. A meta-matrix (Miles & Huberman, 1984) was developed to summarize all of the relevant findings.

Table 1

THE NUMBER OF STUDIES REVIEWED BY INDEPENDENT AND DEPENDENT VARIABLE

INDEPENDENT VARIABLES	N of Studies Reviewed by Indep. Variable	DEPENDENT VARIABLES	
		Achievement N	Behavior N
Color	12	8	11
Maintenance	7	4	6
Age	8	7	6
Classroom Structure	21	7	16
Climate Conditions	8	6	5
Density	9	4	9
Noise	12	9	9
Lighting	16	10	12

Note. Column 1 is the list of independent variables. Column 2 represents the number of studies found for each independent variable. Column 3 is the number of studies containing the specified independent variable and achievement. Column 4 is the number of studies containing the specified independent variable and behavior.

The syntheses were focused on the research design used by the researcher of the selected studies to include techniques, population,

instrumentation, and statistical methodology. Miles and Huberman (1984) stated that "qualitative analyses can be evocative, illuminating, masterful, and downright wrong" (p. 240). Therefore, looking at the rigor of the research, all studies were weighed carefully, with stronger data given more weight in the syntheses.

Definition of Terms

For purposes of this study, the following definitions apply.

1. **Student achievement** was defined in different ways in each study. Although most of the studies measured achievement based on standardized scores on designated achievement tests, studies using non-standardized tests and alternative measures of achievement were included. Appendix C provides a table of the measurement instruments or measurement methods used by each researcher.

2. **Student behavior** was defined differently in each study, but included the following measured behaviors: the ratio of the number of suspensions and expulsions to the number of students enrolled in a school or grade level; the ratio of absences to the enrollment in a school or grade level; and, the ratio of the number of incidents of violence, drug use, illegal activities, or other disciplinary actions to the number of students enrolled in a school or grade level. In some studies behavior included attitudes toward school subjects, eye problems, and blood pressure. Appendix C provides a table of the behaviors measured by each researcher.

3. **Facilities** were limited to the built educational environments that encompassed the following variables: acoustics, age, color, natural and artificial lighting, maintenance, density, climate conditions, and classroom structure.

4. **Synthesis** was defined in The ERIC Processing Manual as a literature review which provides "information analysis and synthesis, focusing on findings and not simply bibliographic citations, summarizing the substance of a literature and drawing conclusions from it" (Cooper, 1994, p. 4). In order to review critically the studies, while developing the synthesis, note was made of the strength of the methodology and the research design.

Organization of the Study

This study has been organized into three chapters. Although this is an atypical format for a thesis, it was apparent that this structure made the research most useful.

Chapter 1 contains the introduction, purpose, significance, scope, limitations, methodology, definition of terms, and organization of the study.

Chapter 2 contains the critical reviews of the studies.

Chapter 3 contains the summaries of the findings and conclusions from the studies, the meta-matrix developed from the studies, the model developed from the conclusions, recommendations from the researchers and recommendations for further study, and a discussion of implications of practice and the related problems for continued research.

CHAPTER 2

CRITICAL REVIEWS

The main emphasis of investigation in this paper is the relationship between the building environment and the two student variables, student achievement and student behavior. The major limitation of this type of research is determining the degree to which school facilities can be the actual cause of student behavior and achievement. There have been questions as to "whether the techniques used have been appropriate for separating school effects from other influences on student outcomes" (McPartland & Karweit, 1978, p. 371). However, even if the findings are that only a small proportion of variation in outcome measures results from the physical environment, it is a portion of the variance that can then be controlled through efforts of educators and design professionals.

The independent variables of color, density, facility maintenance, classroom structure, climate conditions, lighting (natural and artificial), noise, and facility age have been used in many of the studies in regard to their effect on the dependent variables of student achievement and behavior. Some studies are cited under multiple variable headings (Table 3, p. 204), if the research contained more than one independent or dependent variable. When a study is cited multiple times, only the first reference to the study is a complete

description. Subsequent citings address only the information that relates to the variable in that particular section of the document.

The following is a synthesis of the research by independent variable since 1980.

Critical Review of Studies

Color

Porter (1982) has stated that there is a renewed interest in the importance and potential power of color, but the body of research concerning the influence of color has not exhibited a substantial impact on the planners of school facilities. For many

years studies were being conducted outside of education about the reported ability of colors to affect body posture, attitudes, or production. Although the findings in these studies can be generalized to the classroom environment, it is important for a literature base to be developed with student-related variables.

Twelve studies were identified which had color as one of the variables. These studies are presented with a description of the researcher's methodology and findings.

Bross and Jackson

The hypothesis of this study was that room color would affect student performance. Bross and Jackson (1981) conducted their research based on preferred and nonpreferred room color by seventh, eighth, and ninth grade female students. These students were given a "Room Color Preference

Questionnaire" twice, one and two weeks prior to being tested on a mirror-tracing task. Fifty of the sixty students responded the same on both questionnaires. The ten students who did not respond the same way were discontinued from the study.

The students were tested in cubicles with walls constructed so that the color could be changed to accommodate various colors. An electric Marrietta Mirror Tracer was used for the task, with an error counter built into the apparatus to record the accumulation of errors by the students.

Subjects were assigned randomly to groups and were required to practice the mirror-tracing task as a pretest in a neutrally colored room until a criterion score was achieved. An analysis of variance showed there was no significant difference among the three grade levels in initial ability.

Group A of the students was tested individually in the preferred colored room before moving to the nonpreferred colored room. Group B started in the nonpreferred colored room and then moved to the preferred colored room. All of the procedures were standardized prior to student participation, but the subjects were not informed of the nature of the research.

Two t-tests were computed to determine the effect of order. Data demonstrated that the order of the testing was not significant.

The dependent measure of errors and time to complete the tracings were computed for each of the six trials. A 2 x 3 analysis of variance with repeated measures on the second variable was used to analyze the data. Only the eighth

graders improved their time in the room with the preferred color. Errors decreased in the preferred colored room, but the main effect on the group was nonsignificant. The hypothesis that room color affected performance was only partially supported by the data.

Cash

In a study to examine the relationship between the condition of school facilities and student achievement and student behavior, Cash (1993) included the entire population of small, rural high schools in Virginia to conduct her study. The definition of building condition was controlled by an instrument, the Commonwealth Assessment of Physical Environment, and was completed by personnel in the forty-seven schools identified as small and rural. Student behavior was determined by specific definition, as was achievement. In addition, achievement scores were adjusted for socioeconomic status. For the purposes of this section of the synthesis, Cash's study will be reviewed in relation to its findings on color.

Cash found that student achievement was higher in buildings with higher quality ratings. Generally, when conditions were subdivided into structural and cosmetic conditions (Table 2, p. 16), achievement appeared more directly related to cosmetic factors; although, science achievement was higher in buildings with better science facilities.

Table 2

STRUCTURAL AND COSMETIC ITEMS ON THE COMMONWEALTH ASSESSMENT OF PHYSICAL ENVIRONMENT

Structural Building Items	Cosmetic Building Items
1. Building age	6. Interior Wall Paint
2. Windows	7. Interior Paint Cycle
3. Flooring	8. Exterior Wall Paint
4. Heating	9. Exterior Paint Cycle
5. Air Conditioning	12. Floors Swept
10. Roof Leaks	13. Floors Mopped
11. Adjacent Facilities	14. Graffiti
16. Locker Condition	15. Graffiti Removal
17. Ceiling Covering	21. Classroom Furniture
18. Science Lab Equipment	22. Grounds
19. Science Lab Age	
20. Lighting	
23. Wall Color	
24. Exterior Noise	
26. Student Density	
27. Site Acreage	

Cash was concerned that economic factors would impact the study, but she found low coefficients between the two factors of building condition and the Virginia Local Composite Index. In addition, a Pearson's correlation coefficient revealed a low coefficient between building condition and the socioeconomic proxy variable regarding free lunch. Thus, the results of the study associated higher achievement with several physical elements to include schools with pastel painted walls instead of white walls in instructional areas.

Finally, building condition and student behavior factors were related, but this relationship was not the model that Cash had predicted. Schools with better

maintained facilities reported higher incidents per student ratios of violence/substance abuse, suspensions, and expulsions. Cash hypothesized that this could have occurred because personnel in buildings which are maintained at a higher level may administer discipline more frequently and in a stricter manner.

The significance of this study for color was that pastel painted walls were an indication of a physical element that positively influenced student achievement. This was indicated when compared to schools that had walls painted white in instructional areas.

Chan

Chan (1980) conducted a state-wide study of 191 public schools in Georgia to ascertain how the physical environment affected eighth grade students. The null hypothesis was that there would be no significant difference between the academic achievement of students in a facility with interior pastel coloring when compared with the academic achievement of students in school buildings without interior pastel coloring.

The data were obtained from the results of the students' performances on the Iowa Test of Basic Skills and from demographic information from a questionnaire completed by the principals of the middle schools. The questionnaire sought information about the pupil's environment and the number of students participating in the free and reduced school lunch program.

Analysis of covariance was used to compare the achievement scores. The percentage of paid pupil participation in the school lunch program was used as a covariant to control the variations in achievement because of socioeconomic elements. The effects of variables such as teacher credentials, student-teacher ratios, and per pupil expenditure were minimized by using only standard schools in the study.

This study did not show a significant relationship between the physical environment and student achievement. However, because achievement was higher in schools with interior pastel colors, Chan concluded that the overall

impact of the physical environment on middle grade achievement was supported. This conclusion was not supported by the data.

Cohen and Trostle

In 1990 Cohen and Trostle completed research designed to study how school-age children selectively discriminate among school-related environmental setting characteristics. They hypothesized that children are influenced by such environmental characteristics as color, shapes, light, and the complexity of their surroundings. The researchers also attempted to discover if girls and boys responded differently to environmental features such as colors, shapes, and light.

The students participating in the study were seventy-eight kindergarten and first-grade children from public school. There were thirty-two boys and forty-six girls from this rural, middle-class community.

A preference paradigm of the physical characteristics of size, shape, color, complexity, texture, and lighting commonly associated with students' environmental settings was created. This was accomplished by guiding students through a story-walk. Each characteristic was systematically presented to the student in several settings, incorporating the school and play areas.

The settings represented an indoor and an outdoor scenario. Each scenario contained eighteen five-by-twelve-inch laminated posterboard cards, comprising thirty-six stimuli. The indoor pictures consisted of drawings and samples representing school buildings, walls, furniture, and play-area

arrangements in the classroom. Each card featured the selected variable under three degrees of size, intensity, or complexity. The students selected the one stimulus with the greatest personal appeal. Testing consisted of two ten-minute sessions arranged over a three-day period, conducted by a familiar, nonteaching adult.

The responses of the participants were converted to quantitative scores. Females scored higher in indoor and outdoor settings for the dimensions of complexity, color, texture, and lighting. Males showed a greater preference for large-size settings. Older children showed a preference for multishaped objects, more complexity, more dramatic color, and more intense lighting effects. Indeed, the results of the testing in regards to color, multidimensional shapes, brighter lighting combinations, and more detailed use of scenic arrangements were very significant for the girls in the study. The study raised important questions pertaining to the possible influence of socialization practices and related opportunities presented to boys versus girls regarding environmental exploration and its influence on children's later environmental cognitions.

However, the findings only dealt with student preferences with respect to color in combination with other variables. The researchers did not address specific colors or the effects of color on achievement or behavior.

Earthman, Cash, and Van Berkum

These researchers addressed the possible relationship between student achievement and behavior and the condition of the facility in which students learn. They hypothesized that the condition of the built environment would influence student achievement and behavior.

The dependent variable, achievement, was measured by the Comprehensive Test of Basic Skills, and the variable, behavior, was measured by the number of disciplinary incidents reported per pupil for the school year. North Dakota was selected as the site for the research because of the historical information documenting high Scholastic Achievement Test scores. This state, also, historically has had a relatively homogeneous rural population.

School principals were given an evaluation instrument to record the presence or absence of selected facility conditions. From this document, the school building was ranked as above standard, standard, or below standard. This ranking was conducted with 199 high schools ranging in size from 65 to 1200 students. Principals from 120 schools responded to the questionnaire.

Color was one of the items addressed in the facility instrument, along with interior paint and paint cycle. Score means were higher in buildings rated above standard for the condition of the interior; however, there were no statistics available when the wall color was rated as to its effects on achievement.

When reporting on the behavioral variable, there were more reported disciplinary incidents in above standard buildings than in substandard buildings.

Grangaard

Grangaard (1995) attempted to replicate a study by Wohlfarth in 1981 to determine the physiological and behavioral effects of color and light on elementary students. There were three phases in the study in which the color and light of the test field were manipulated.

In Phase I, students were placed in a classroom environment in which there was student artwork and other items on the walls, bulletin boards of red and orange, and white semi-gloss walls with cool-white fluorescent fixtures. In Phase II, students were in a classroom where the walls were painted a light blue, the visual noise on the walls was normal, and the lights were a full-spectrum duro-test vita-light. In Phase III, students were returned to the original environment of Phase I.

Only eleven six-year-old elementary school students participated in the study, so the results are based on a very small sample. These eleven students were video taped for fifteen minutes at the same time each morning during the same activity and for fifteen minutes in the afternoon, for a total of three ten-day phases. Three educators were trained in procedures to count the off-task behaviors to be identified from the videos. The students' blood pressures also were taken at the same time each day, once in the morning and once in the afternoon. The researcher began taking blood pressures two weeks prior to the beginning of the study in order to establish a base line.

The study was conducted during a seven week period, and the observers noted a total of 1,110 off-task behaviors. In Phase I, three hundred ninety were counted, which compared to three hundred ten off-task behaviors during Phase II. Color and light were the only noted changes during these two phases. During Phase III, an increase over Phase II of one percent in off-task behaviors was recorded.

The group mean systolic blood pressure decreased dramatically (nine percent) during Phase II or in the psychodynamically prescribed environment. Computer generated graphs demonstrated lower coordinates nearly each day of the study. Grangaard noted that it is the learning environment within which humans spend a large part of their early lives. She stated that "research has demonstrated the fact that there is a cause/effect relationship between the biological organism and its environment. . ." (p. 6).

Hines

Hines (1996) conducted a study very similar to Cash (1993) and Earthman, Cash, and Van Berkum (1995). However, Hines targeted large high schools, rather than rural high schools as Cash had done or varied sizes of high schools as in the North Dakota study. Hines hypothesized that there would be a relationship between the condition of school buildings and student achievement and behavior in urban high schools in the Commonwealth of Virginia. Color was one of the cosmetic variables that Hines considered.

The condition of the buildings was determined by the Commonwealth Assessment of Physical Environment that was completed by personnel in the divisions of the participating schools. Conditions were divided into three groups: substandard, standard, or above standard. Student achievement was assessed by the scale scores of the Test of Academic Proficiency for grade eleven. All achievement scores were adjusted for socioeconomic status by using the free and reduced-priced lunch eligibility. The number of expulsions, suspensions, and violence/substance abuse incidents compared to the number of students in each school was used to measure student behavior.

When analyzing the question of wall color, the walls in the classrooms were painted in dark colors (N=0), white (N=16), or were painted in pastel colors (N=49). Those with white walls reported mean scale scores of 196.36 and those with pastels scored 197.80 in Grade 11 (Test of Academic Proficiency). Color did not appear to have a great impact on achievement or behavior; neither did the frequency of painting.

Sydoriak

Sydoriak also addressed the question of the effects of color and light combinations on students in the learning environment. The color treatment segment of the study focused on the difference in the effects of robin's egg blue walls and antique white walls in combination with cool-white light and full-spectrum fluorescent lighting. Ninety-six third grade students from four elementary schools in Arkansas participated in the study that included a design of three artificial light sources.

To study the effects of the two independent variables, color and light, the design required four treatment groups and two comparison groups. One group performed in a classroom with cool-white fluorescent lighting and robin's egg blue walls and was compared to the same conditions with antique white walls. Another segment of the study was conducted with students in treatment groups with full-spectrum fluorescent lighting and robin's egg blue walls in comparison with a treatment group with cool-white fluorescent light and antique white walls. Students were subjected to the treatments for approximately seven months.

The Iowa Test of Basic Skills was used as a pretest and as a post-test. Blood pressure readings were taken for all of the students from each treatment group. The readings were taken once per month on a pre-determined schedule during the study. The initial height and weight for each student in each treatment group were measured and recorded at the beginning and at the end of the study. Analysis of variance was used to analyze the data. The purpose was to

determine whether the differences between two or more group means were greater than would be expected by chance alone.

Sydoriak (1984) was fortunate to be working with a school division that permitted classrooms to be modified for the treatment. Students in the classrooms with relaxing shades of blue had significantly lower blood pressure readings. The results of this study were not significant in the segments that attempted to analyze color and cool-white or full-spectrum fluorescent lighting combinations.

Wohlfarth

Wohlfarth (1986) designed a quasi-experimental study to address factors which differed from the traditional focus on curricula and instruction. He focused his attention on the physical setting in which learning takes place, specifically, the effects of color and light in the elementary classroom. Four schools were involved in the study; three served as the experimental group and one as the control.

The researcher addressed several questions, including what effects during one school year would be attributable to simulated natural light, prescribed colors, and experimental light/color combinations on mental development, scholastic achievement, attitudes toward school subjects, misbehaviors, absences, eye problems, and blood pressure. He also addressed the effects of prescribed color/light combinations on noise levels.

Pretesting of students' abilities and achievement levels was completed during the year prior to the study using standardized tests. Post-testing was completed after the students had progressed a grade and following a ten-month exposure to the treatment effects of color/light combinations, light only, or color only. Analysis of covariance was used to adjust post-test averages and establish statistical equivalency. During the project year, all students were given vision tests designed to demonstrate eye muscle balance and visual acuity. Moreover, students were assessed with various instruments for particular moods and attitudes. Student behaviors requiring disciplinary actions and absences because of illness were recorded by school staffs.

One of the independent variables for the student related portion of the study was exposure to prescribed warm colors for students or a combination of light and color treatments. There were no consistently strong cause-effect relationships between a ten-month effect of simulated outdoor light or prescribed colors or light/color combinations in the school environment and student ability or achievement levels, attitudes towards school subjects, misbehaviors warranting disciplinary action, absences due to illness, refractive eye problems, or blood pressure. Although no strong relationships to blood pressure were found, there was some indication that color has a short term effect on students' blood pressure levels. Warm, stimulating colors were associated with increases in students' blood pressures. However, in the experimental schools, where color

was a treatment variable, the blending of cool and warm colors in the same classroom was a fault in the research design.

There were important differences observed between students in the control and experimental schools in pre-adolescent mood levels. Children in the color/light and light only schools exhibited greater feelings of urgency and mastery/self-esteem. The color only school had the lowest levels of self-esteem, and the control and color/light school were the highest on aggression.

The study of noise levels using a pre-experimental static group design between the architecturally twinned control and color/light schools revealed important differences with the color/light school in that they were consistently quieter than the control school.

Although the findings in this study were limited, significance was found to the extent of there being increased self-esteem, less noise, and higher levels of mastery in the experimental schools with the light/color combination.

Yielding

Yielding (1994) observed, recorded, and described the interface between the educational facility and the learning climate. One of the hypotheses was that illumination, noise, color, thermal environment, density, location, maintenance, esthetics, and safety do affect students' and teachers' reactions and behaviors. The researcher was guided by an extensive review of the literature on the effects of facilities. The design of the study was based primarily upon naturalistic inquiry techniques and replicated a similar study in 1990 in Texas.

Several steps were implemented to ensure the validity of the results: the researcher became familiar with the school district's policies, procedures, rules, and regulations; extensive observations were employed; and, in-depth survey techniques and on-site observations were performed. These data were recorded in a systematized manner, and instruments were used to assess the perceptions of teachers relative to the relationship of the facilities to learning climate. The results of the assessment of teacher perceptions, as well as the recorded observations of students were codified, categorized, and summarized.

Three schools in Alabama were chosen for the study that had an organizational structure which included kindergarten through second grade. The age of the school buildings was similar, and the populations included one school with 232 students, another with 175, and the largest with 521. Although this study did not directly address the behaviors and achievement of the students, the results of interviews with the teachers adequately evidenced a relationship

and interface between the facilities and learning climate in all schools studied. Although, the impact of actual colors or shades of colors were not addressed specifically in this study, the concepts of space, equipment, color, lighting, maintenance, appearance, comfort, and general physical arrangement positively or negatively affected the learning climate of the schools. Therefore, there are strong implications that students are positively or negatively impacted.

Zentall

The study of the effect of color stimulation on performance and activity of hyperactive and nonhyperactive children was the purpose of an investigation by Zentall (1986). The stimulation caused by color was measured with a repetitive vigilance task and a complex learning task.

A small experimental area in each school was partitioned off from the experimenter and equipment by three tan screens. Each child was seated individually at a small desk to which response buttons had been taped. As students were presented with tasks, each child's activity was recorded by means of activity meters. Hyperactive and control children were randomly assigned to treatment conditions with the constraint that equivalent numbers of hyperactive and control children from each grade level were represented in all of the conditions. Chi-square analyses, analysis of variance, and other statistical methods were used in assessing the data.

Sixty-six hyperactive children from twenty-three regular education classrooms from grades one through six participated in the study. Children were

selected first, on the basis of their total score on a hyperactivity rating scale, and secondly, on the hyperactivity, attentional, and impulsivity items to indicate attentional deficit disorder. Eighty control children, equivalent to the experimental groups in chronological ages and mental ages and achievement, were selected from the same classrooms based on low attentional deficit disorder items scores and on low Davids scale scores.

Although this research did not focus specifically on color in the environment, it did study color as a part of the tasks performed by students. The results were so very powerful when considering how color added to task stimuli, that the researcher hypothesized that added environmental stimulation effects may be as powerful as those obtained with stimulant drugs.

Accepted theory prevalent in education over the last forty years has suggested that stimulation, distracting tasks, and environment exacerbate hyperactivity. The findings in this study indicated that the requirement for sustained attention to minimally stimulating tasks sets the occasion for hyperactivity. Hyperactive children performed as well as normal children, and they are less active when color stimulation was added to rote tasks. These children derived great gains from added stimulation during the performance of minimally stimulating tasks, because they were less tolerant than normal children of low levels of stimulation.

Zentall and Kruczek

In a later study, Zentall and Kruczek (1988) hypothesized that hyperactive children are more readily under stimulated than normal children, they exhibit more sensation-seeking activity, and they are more easily attracted to stimulation. Seventeen active attention-problem boys were selected from regular elementary classes on the basis of high scores on the Abbreviated Teacher Rating Scale.

A testing room was used which was set up with two chairs facing each other across a table. The observer sat behind a folding screen, while a copying task was presented to the children. Four treatment booklets were developed for each student from the two treatment variables. Low stimulation booklets had black lettered words; high stimulation booklets contained colored letters. Two different colors were used per page.

Subjects were tested in pairs in a repeated-measures crossover design, such that half of the pairs experienced high-stimulation handwriting tasks for the first thirty-minute session, and the low-stimulation task was administered two weeks later or in the reverse stimulation order. Random-versus-relevant color placement was randomly assigned to pairs of children in each stimulation order with the constraint that half of the pairs were assigned to each emphasis placement. This resulted in a mixed design with stimulation and matched pairs within-subject factors, and emphasis placement the between-subjects factor.

Group was a within-subjects factor because the matching pairs were yoked together in both experimental settings.

Again, the results of this study were not directly related to the environment; however, there were strong indications that color for color's sake was distracting to the hyperactive child. When color was added for emphasis during the performance of a task, attention-problem students performed better. These data supported Zentall's 1986 study.

Maintenance

"Little research has been done on the need to repair and refurbish school buildings because of the impact that the condition of buildings has on the students" (Berner, 1993, p. 6). Indeed, there has been little interest in the condition of public school buildings until recently, when U. S. Secretary of Education Richard W. Riley and Senator Carol Moseley-Braun spearheaded an initiative to improve the problem of school maintenance and the nation's deteriorating education infrastructure. A report by the General Accounting Office shows that one-third of all the nation's public schools need extensive repair or replacement (Agron, 1996). These needed repairs affect fourteen million U. S. students.

This synthesis will highlight six studies which describe the independent variable, maintenance.

Edwards (Berner)

In 1991, Edwards completed an in-depth study of the public school buildings in Washington, D. C. Edwards believed that poorly maintained buildings sent a message to students that the school system was uncaring, and this, in turn, contributed to discipline problems and poor performance in the schools. She hypothesized that the condition of the facility was affected by parental involvement. Given the above, the condition of the school building becomes the dependent variable, while later in her study the condition of the facility is an independent variable.

A regression formula was used for the model of impact of parental involvement on building conditions that included the condition of the school building as a dependent variable, the type of school as an independent variable, parental involvement as two variables (PTA membership and PTA budget), age of the building as another independent variable, two additional controlled independent variables of income and race, and the final independent variable of enrollment of the school. For the model of impact of the condition of the building on achievement, the dependent variable was achievement, and the independent variables included those used in the first model, as well as the additional independent variable, the condition of the school.

Students in 191 facilities were used in the study. These facilities housed approximately 83,000 students. Their achievement was measured by the Comprehensive Test of Basic Skills.

Some of the information on the condition of the school buildings was obtained through a parent advocacy group, Parents United for the D. C. Public Schools. However, the D. C. Committee on Public Education (COPE) assisted in obtaining an impartial perspective on the condition of the facilities by organizing several groups of volunteer maintenance workers, engineers, architects, and other technical professionals to visit each school and report on the building conditions and the adequacy of the facilities. The teams were to estimate the cost of repairing building deficiencies and gauge whether the building was in poor, fair, or excellent condition.

Parental involvement data were limited to a sample provided by the D. C. Office of Parental Involvement. A survey of fifty-two schools served as the basis for this information. Edwards noted in her findings that the small sample size was a weakness in the study.

Demographic characteristics of the neighborhood surrounding the schools were obtained from published U.S. Bureau of the Census data. Other miscellaneous information included in the models was obtained through the D.C. Public Schools Office of Communications.

Age was found to be a strong predictor of the condition of the school. For every nineteen years of increase in the age of the school, the condition of the building worsened by 0.50 on an overall condition scale of one to three. On the other hand, as enrollment increased, the building condition improved. Edwards thought this occurred because larger schools have more resources, finances, or

personnel to deal with repairs. It should be noted, too, that as PTA budgets increased, the condition of the facility improved.

The findings supported with significance that good infrastructure and well-maintained buildings were truly a foundation for quality education. As a school moved from one category to the next with the evaluation of the building's condition, average achievement scores could be expected to increase by 5.455 points. The research indicated that the difference between schools in excellent and fair condition was less important than the difference between schools in excellent condition and those in poor condition.

Cash

In this study which examined the relationship among the condition of school facilities, achievement, and behavior, building principals assisted in determining the condition of the facility. Items such as roof leaks, locker condition, ceiling covering, interior and exterior paint cycles, clean floors, graffiti removal, and many other indicators as to whether or not a facility was well-maintained were rated by the principals.

Student achievement was higher in those facilities with higher quality ratings. In addition, student achievement mean scale scores were related to higher quality cosmetic building condition ratings (Table 2, p. 16) such as better locker conditions, less graffiti, furniture in better condition, and schools with better custodial care.

The unexpected response was that better maintained facilities had higher incidents per student ratios of violence and substance abuse, suspensions, and expulsions. Cash, as did Edwards (1993), contributed this to the potentially higher expectations of the administration and staff in buildings that were well-maintained.

Cheng

The study was conducted in elementary schools in Hong Kong to study the relationship between student affective performance and classroom physical environment, social climate, and management style. Cheng hypothesized that the physical environment would affect the behavior of students.

A cross-sectional survey was used. The researcher developed an instrument of eleven items to assess the physical environment of the classroom that included spacing, neatness, cleanliness, and lack of pollution. There were 678 predominantly sixth grade classes from 190 primary schools with approximately 21,622 students included in the study. The sample size represented sixteen percent of the school population. In the sample schools, all of the sixth-grade classes were selected. When there were no sixth graders, the fifth grade was used.

The findings in Cheng's research indicated that self-concept of the students was not related to the perceived physical environment; however, students' attitudes toward teachers and school correlated strongly and positively with the perceived quality of the physical environment. Attitudes toward

homework and intentions to drop out were negative indicators when correlated with the perceived quality of the physical environments. It should be noted, as well, that perceptions of the students were closely related to the perceptions of the teachers.

The quality of the physical environment related substantially to nearly all of the measures of student affective performance, except self-concept. Effective classrooms were perceived as being equipped with appropriate physical facilities, having enough space, and being neat, clean, and free of pollution.

Earthman, Cash, and Van Berkum

This study was similar to the studies by Cash and Hines in that the methodology was the same. The difference in this research, however, was that the three researchers used all of the high schools in the State of North Dakota that ranged in size from 65 to 1200 students. Again, principals were used to rate their buildings. The survey instrument rated twenty-five items in the physical environment. Achievement was measured by the Comprehensive Test of Basic Skills (CTBS).

In eleven of thirteen achievement components of the CTBS, the percentile and scores of students in the above standard schools were higher than the scores of students in the substandard schools in the context of the overall building condition. When making the comparisons with cosmetic conditions of the building, the students in the above standard school buildings scored higher than those in the substandard buildings on twelve of the subtests. Although the

margin was small, there were more disciplinary incidents in the above standard buildings than in substandard buildings.

Students scored higher on the CTBS in above standard facilities (as rated by the State Assessment of Facilities in Education) when the following items were reviewed: windows, floors, heat, roofs, adjacent facilities, locker conditions, ceilings, laboratory age, lighting, interior point, interior point cycle, exterior paint cycle, mopped floors, graffiti, grounds, cosmetic opinions, structural opinions, overall opinions, and density. Composite results would reject the null hypothesis for student achievement and retain the null for student behavior.

Hines

This study replicated the study in North Dakota and the one that Cash conducted in small, rural high schools, except that Hines worked with high schools in metropolitan areas with populations of over 100,000 and school enrollments of over 25,000 students.

School personnel completed the Commonwealth Assessment of Physical Environment (CAPE) to determine the condition of buildings in their divisions. Buildings were ranked into three groups by using the CAPE: substandard, standard, or above standard. Building scores were divided further into cosmetic and structural conditions.

Higher achievement was associated with higher frequency of exterior painting, schools that were mopped more frequently, expedient graffiti removal, better locker conditions, better classroom furniture, and better landscaping.

In summary, scale scores improved on every subtest of the Test of Academic Proficiency when substandard buildings were compared to above standard buildings as determined by the CAPE. The overall improvement denoted a very strong relationship and supported the research question in the hypothesis about achievement.

Behavior was evaluated as the Cash and Earthman studies had been done, and was adjusted for socioeconomic status by using free and reduced lunch eligibility. With student behavior, the conclusions were not as clear. Suspension, expulsions, and reports of violence, as in Cash's study, were positively correlated as the building conditions moved from substandard to standard. However, when comparing substandard to above standard, the null hypothesis was rejected.

Karst

In 1983 Karst reported to the CEFPI that there were differences in teacher and student attitudes when attitudes concerning facilities were measured. First, six schools were analyzed and rank-ordered by their total scores on the MEEB, a measurement structure developed by McGuffey. Next, they were matched according to user attitude inventory total mean scores. Finally, analyses were completed according to school quality of "top" schools versus "bottom" schools.

The six schools included three elementaries, two junior high schools, and one high school. Four hundred students and 130 teachers were randomly selected from the schools, located in a large metropolitan area, to participate in

this study. Data were collected on user attitudes. From these inventories, both descriptive statistics and inferential independent t-test statistics were applied.

The teachers and students were studied in respect to both attitude inventories and objective quantitative measurements. However, the study was not designed to measure the site factor. This prohibited the researcher from making comparisons between teachers and students by physical plant quality and by site.

Regardless of the condition of the facility, the data showed that on total scores, teachers had significantly better user attitudes than students. Some evidence seemed to suggest that the number of significant differences between student and teacher attitudes were less when looking at the top three maintained schools. Students nearly always had significantly poorer user attitudes than did their teachers across schools and within their own schools.

Finally, students in the poorer rated rooms, also, had significantly poorer user attitudes in the bottom schools than did the students from the top schools ($p < .001$). This research did not progress to demonstrate the effects of student attitudes about facilities on performance.

Yielding

Again, this study is being mentioned even though the variables of student achievement and behavior were not a part of the research. Yielding (1994) replicated a 1990 study in Texas by using naturalistic inquiry techniques with teachers in three elementary schools. In the assessment of teacher perceptions, the reactions of classroom instructors to such physical features as equipment, color, lighting, maintenance, and other building features were very enlightening. Teachers had specific preferences regarding the safety, aesthetic, instructional, and equipment features of their classrooms, and should be involved in the development of educational specifications when renovation or new construction is necessary.

More than adequate evidence was presented to indicate that there was a relationship and interface between the facilities and learning climate in all schools used in the research in Alabama and Texas. If this is the perception of the teachers, it is likely to affect students in some manner.

Age

In the July, 1996, update of a publication from the Virginia Department of Education, School Facility Status Survey, it was estimated that "the majority of Virginia's schools need major renovation or replacement (63%)" (p. 9). Schools built in the 1960's are not only inadequate learning environments, they were only designed for a thirty-year life span.

Escalating construction costs, which are increasing at a rate much higher than the rate of inflation, exacerbate the age issue. Increasing costs hamper the building of new schools and the renovation of outdated school buildings.

The next portion of this research synthesis may provide the data necessary for administrators and politicians to make research based decisions in the area of facility age. Seven studies will be reviewed.

Edwards (Berner)

Age was an independent variable in Edwards' (1991) study of building condition and parental involvement in the District of Columbia Public Schools. The data from the survey of the schools indicated three variables as having significant influence: school age, school enrollment, and the PTA budget.

The age of the school building was a strong predictor of the building condition. For every ten-year period added to the age of the school, the condition of the building worsened by 0.50 on a one to three scale of overall condition. The research indicated that routine maintenance for most facilities becomes more important as a facility ages. Therefore, if funds are not expended

on maintenance, major repairs, and refurbishment, the condition of the building worsens with age.

A problem with Edwards' findings in regard to age was the fact that the parameter estimate was fairly small.

The second hypothesis was developed to link building condition to student achievement. As a school moved from the poor condition category to fair, overall achievement scores increased by an average of 5.455 points. If a facility improved its condition from poor to excellent, the achievement score increase averaged 10.9 points.

Conversely, as the condition of a school building worsens with age, the older a school was, the greater negative impact that facility would have on a student. This was significantly noted in Edwards' study, as both in the all-schools and the surveyed-schools data set, the sign of the estimated building condition coefficient was negative. Therefore, as the condition of the facility improved, so did the average student achievement scores.

Edwards (Berner, 1993) summarized that, "Good infrastructure is truly at the base of quality education" (p. 28).

Bowers and Burkett

Bowers and Burkett (1988; 1989) conducted research under the premise that student learning would be directly related to the physical environment of the respective facilities. The researchers began the study with the hypothesis that

achievement and self-concept of students would be improved significantly in modern school buildings.

Two hundred eighty randomly selected fourth and sixth grade students in two facilities were the subjects of the study. Principals, teachers, and socioeconomic levels of the communities were similar. The variable of age of the facility was the only difference when comparing the achievement and self-concept of the students.

ANOVA and t-tests for independent data were used to analyze the data and test the hypotheses. The Piers-Harris children's self-concept scale was administered to students in the fifth and seventh grades in the two schools.

Students in the modern building scored significantly higher in reading, listening, language, and arithmetic than did students in the older facility. The significance was greater than the .01 level. Discipline was needed less frequently in the new facility versus the less desirable physical environment. This was true, even though the new school had a larger enrollment. The level of significance for analysis purposes was .01.

Students in the newer building had significantly higher attendance records and seemed to have better health records. Self-concepts of the students in the newer facility were better than those of students in the older school. Bowers and Burkett deducted that a significant difference existed between students at the two elementary schools in regard to the relationship of the physical environment and student achievement.

Cash

On the Commonwealth Assessment of Physical Environment the very first item asked for information related to the age of the facility. Buildings fifty years old or older were identified as one; buildings at least twenty years old, but less than fifty years old, were identified as two; and, buildings under twenty years old were identified as three. Cash (1993) had facilities represented in each condition group in her study.

There was a difference of three scale score points between all buildings twenty years old or older and younger buildings. Younger buildings had a composite mean scale score of 191 on the Test of Academic Proficiency, while the other facilities had a composite mean scale score of 188.

Chan

Chan (1982) conducted a comparative study of student attitudes toward a new school versus an old school. The researcher had four hypotheses. There was no significant difference between student attitudes toward a new building and attitudes toward an old building, no difference in attitudes of males and females toward old and new buildings, no significant difference in the attitudes of students compared by race toward old and new buildings, and no significant difference in attitudes of paid school lunch participants and the attitudes of the free and reduced price school lunch participants toward new and old school buildings.

The design for Chan's study was a non-equivalent control group design of a quasi-experimental nature. Pre-test and post-test scores on an "Our School Building Attitude Inventory" were the dependent variable. The independent variables included the physical facilities in the three school buildings, the student's sex, race, and socioeconomic status. Analyses of covariance and variance were used to examine the variables.

The control group consisted of the 119 students in Grades 2, 3, and 4 in a school built around 1936. The experimental group consisted of all 96 students in Grades 2, 3, and 4 in a 1923-constructed building who were transferred to a new school when it was completed.

After statistically adjusting the post-test scores of the control group with the corresponding pre-test scores of the experimental group, students in the experimental group scored an average nineteen points (on a 55 point scale) higher than students in the control group. The difference in attitude scores was indicated by an F-value of 19.71, which was significant at the .0001 level. The effect of sex, race, and socioeconomic status on student attitudes was examined in the pre-test and post-test scores of the control and experimental groups. Race and socioeconomic status had no effect on student attitudes toward their school buildings. However, female students in the control group scored significantly higher than males on both pre- and post-tests. All were significant at the .05 level.

Chan summarized evidence of significant findings that rejected the nulls, except when gender was introduced to the study. His findings indicated that the physical environment did affect student attitudes.

Earthman, Cash, and Van Berkum

This recent study (1995) involved the dependent variables of student behavior and achievement. In 199 high schools in the State of North Dakota, building age was not a determining factor in student achievement. This was true, as the researchers looked at building age, air conditioning, noise, exterior paint, and acreage of the site.

Students scored higher on the CTBS in above standard facilities when items such as windows, floors, heat, roofs, locker conditions, ceilings, laboratories, lighting, interior point, interior paint cycle, exterior paint cycle, mopped floors, graffiti, grounds, and density were used as the variables. If all of these had a positive effect on student achievement, it does not follow that building age was not one of these elements causing increased achievement.

In summary, school facilities ranked as below standard had students who scored higher on the CTBS.

Garrett

Garrett (1980), too, looked at the impact of school age on the achievement of students in the State of Georgia. He hypothesized that when the socioeconomic status variable was statistically controlled, the age of a facility would have a significant relationship to the achievement of students (hypothesis

1). The researcher went on to say that the achievement of students taught in non-modernized school facilities would be significantly lower than those taught in partially modernized or modernized schools (hypothesis 3).

The design for the research was *ex post facto*. The data were gathered from the results of a questionnaire about the facility, which was sent to schools that had an eleventh grade, and from the results of eleventh grade students' scores on the Test of Academic Progress. Information included in the facilities questionnaire was the original date of building construction; the total number of eleventh grade students; the number of students not participating in the free and reduced lunch program; the status of air conditioning, carpeting, and lighting; and, how recently the classrooms had been painted.

In order to allow the variables with the largest amount of variance to enter the equation first, the hierarchical inclusion method in multiple regression was used to analyze the relationship between the dependent variable, achievement, and the independent variables of building age and socioeconomic status. Hypothesis 1 was tested by the F-test to determine if the observed relationship was significant. Analysis of covariance was used to test hypothesis 3. Socioeconomic status (SES) was used as a co-variate.

When the SES variable was statistically controlled, the age of the facility made a significant difference in student achievement in composition, reading, and mathematics scores on the Test of Academic Progress (.01). The achievement of students taught in non-modernized school facilities was not

significantly lower than those taught in partially modernized schools. However, achievement of students taught in partially modernized schools was significantly lower than those taught in modern facilities. Finally, when the effects of socioeconomic status variables had been controlled statistically, an analysis of covariance was used to compare the composition scores of students in modernized facilities and the composition scores of students in non-modernized schools. The differences were significant.

As the age of the facilities decreased, there was a corresponding increase in mathematics, reading, and composition scores, indicating a negative correlation. Garrett concluded that student attitudes are affected by the quality of the learning environment, that students preferred new or modernized facilities over older classrooms, and that student productivity was affected by student comfort as facilitated by the modern environment.

Hines

Hines' (1996) study was previously reviewed in this synthesis with respect to the independent variables color and maintenance; however, the researcher also presented data that was very meaningful when the age of the facility was considered. The Composite Scale Score Means for the substandard facilities was 192.70; for the standard condition buildings, the score was 194.77. The score for above standard school facilities was 200.10. The scores increased over the conditions with a total of slightly over seven additional points when substandard buildings were compared to above standard.

The researcher noted that on every subtest of the Test of Academic Proficiency, achievement scale scores improved when substandard buildings were compared to above standard buildings as determined by the CAPE. Building age was one of the variables that showed a very strong relationship.

The results derived from student behavior were not as clear. As concluded by Cash (1993), Hines found that a "better maintained building promoted higher diligence in maintaining discipline and demanding more acceptable behavior" (76).

Pritchard

Pritchard (1986) aimed to compare selected measures of the academic performance of tenth grade students before and after a school merger, and to compare the perceptions of school climate of both tenth grade students and their teachers just prior to and after the movement of teachers and students into a single new facility. The CTBS Reading Vocabulary, Reading Comprehension, Mathematics Computation, and Mathematics Application of Concepts subtest scale score means of tenth grade students from the new, merged high school were predicted to be higher than score means of students from the former three unmerged schools. It was assumed also that the new school would have higher school climate subscale means on the Connecticut Effective School Assessment instrument.

Analysis of variance, Tukey-B multiple range tests, and the t-tests for independent samples were used to discern significant differences among and

between groups. A total of 125 tenth grade students from the three pre-merger high schools participated in the study, compared with a total of 281 tenth graders from the new high school.

Tenth grade students from the post-merger school achieved significantly higher scale score means on the CTBS reading comprehension and mathematics computation subtests than tenth grade students from the pre-merger schools. However, tenth graders from pre-merger schools achieved significantly higher means in reading vocabulary, mathematics concepts, and application subtests than tenth graders from the post-merger school. Thus, Pritchard stated that there was no overall basis for the assumption that student proficiencies in reading and mathematics were enhanced under conditions created by the new school.

The researchers suggested that the findings may have been affected by the relatively short period of time between pre-merger and post-merger conditions. There were, however, highly favorable perceptions by students and teachers of the post-merger school. Pritchard believed that this improvement would eventually foster significantly higher test scores for the students on both teacher-made and standardized examinations.

It should be noted that the researcher did not see this study as an old versus new facility, but as a small school versus a larger school.

Classroom Structure

Years ago, learning was "considered a passive activity" and students were seen as empty vessels into which knowledge was poured (Dyck, 1994, November, p. 42). Little thought was given to the arrangement of the furniture, the shape of the classroom, or the myriad of items of which a classroom consists. Indeed, even in this era, more consideration may be given to finding the funds to furnish or to build the classroom than is given to designing and building a research based facility.

Does the shape or structure of the classroom affect what goes on inside that room? Does the architectural environment directly affect the cognitive and social development of the student? (Christopher, 1995). Twenty studies that identify classroom structure as the variable will be reviewed in this portion of the synthesis.

Ahrentzen and Evans

The design variables of this study included degree of classroom perimeter openness, area volume, and provision of space for independent study. A single interviewer questioned all participants in the study. A questionnaire was used with both open-ended and closed-ended questions. Before the interviews began, it was shown that all children were able to understand the interview process.

The authors organized the physical features of a classroom into three clearly defined and delineated categories: interior spaciousness, perimeter

structures, and privacy amenities. Sixty-five randomly selected students were interviewed from thirteen classrooms of five elementary schools.

Distraction was measured by self-reports. The questionnaire item describing distraction reflected the type of stimulation (aural, visual, and kinetic), the content, the source, and the duration. Spearman-Brown reliability coefficient for the distraction items was .80.

The findings indicated that few architectural features affected student distraction. While the percentage of structural walls showed a moderate positive relation to classroom satisfaction, it was not associated with visual, kinetic, or aural distraction by students in the study. Percentage of open perimeter space was unrelated also to distraction, but it was associated with less classroom satisfaction. Students reported more kinetic distraction and less visual distraction in rooms with greater ceiling height.

Student satisfaction ratings were unrelated to interior spaciousness and negatively associated with percentage of open perimeter space. Distractions that teachers observed were not noticed by the students. This finding may be very significant to educators and designers.

Provision of secluded study spaces and single desks was associated significantly with less perceived privacy in the classroom by students. The researchers believed this result was tainted by their limiting the definition of privacy, because the descriptive data revealed that students wishing to be alone

or to concentrate do prefer secluded study areas or corners of the room. However, teachers should not permit students to be out of the line of vision.

Burgess and Fordyce

These researchers (1989) examined interpersonal spacing patterns of toddler-aged students in differently designed classroom environments and the related individual differences in the nonverbal behavior of the participants that resulted. Observations were made of free-play at specified times each morning. Teachers were aware of the observations, but they did not know the specifics of the study.

The children were observed in three environments: (1) an open, spacious classroom with six square meters of floor space per child; (2) a large play area outdoors adjoining the classroom; and, (3) a divided classroom that was identical to the open classroom, except that three bookcases were arranged in the center of the space. The bookcases were toddler height, in order that the teachers would not lose observation capabilities.

Photographs were taken of the class daily to ascertain the position of every child and caretaker and to plot that position on coordinates. Each child was documented in approximately four observations. Scores were calculated for each child's distance to the first through the fifth nearest classmate and teacher. Spacing distances were compared by three-factor repeated measure analyses of variance. Gender differences in distance were contrasted in a mixed-model ANOVA; *a priori* comparisons were made by single-factor ANOVA using the

group error term; and, multiple comparisons were made by using Tukey's all-pairs test.

Only twelve students participated in this study. When these children were given additional space with or without dividers, they altered their interpersonal distances. The presence of dividers made a minimal difference in overall spacing, but seemed to cause the students to be less frenetic. This study indicated that there were mild effects of density with toddler-aged students. They may need more classroom space than had been previously predicted.

The results suggested that toddler-aged children may find the typical classroom to be confining. Changing the design of the space to provide open areas did not change children's responses. Visual dividers had little effect on self-imposed spacing, except to allow the students to be slightly further away from their teachers. There were suggestions that the close presence of adults and classmates can interfere with toddlers' free-play in a normal sized classroom, causing them to seek less populated areas of the classroom.

Burkhalter

Burkhalter (1983) hypothesized that there would be no significant differences between the academic achievement and attitudes of students enrolled in an experiential environment and students enrolled in a traditional academic setting. High school students participated in this study by applying to be selected for an experimental group. From the 240 applicants, eighty were selected for the experimental group from vocational centers throughout the State

of Alabama. Because directions were not followed during testing procedures, the experimental group was adjusted to sixty students. These sixty were divided into three subgroups of twenty students each.

The Career Maturity Inventory (CMI) Attitude Scale was the instrument used to measure the attitudes of participants. A criterion-referenced test was developed to evaluate the students' status with respect to the stated objectives of the experiential program.

The Alabama Space and Rocket Center complex served as the home base for the Career Exploration Program. Activities were designed to integrate program content with the physical environment.

The findings supported the concept that a highly stimulating experiential environment provided and promoted a positive attitude toward careers, learning, and, ultimately, achievement. This study had very positive implications for science laboratories in schools, suggesting that students achieve more in settings where they can participate in hands-on activities.

Cohen and Trostle

This study was more thoroughly reviewed in a previous portion of this chapter on colors. As stated earlier, there were seventy-eight kindergarten and first grade children from public schools who were the participants. These students were exposed to various environments with pictures. The indoor pictures consisted of drawings and samples representing school buildings, walls,

furniture, and play area arrangements in the classroom. The students selected the one stimulus in each picture that had the greatest personal appeal.

When the responses were converted to quantitative scores, mean scores for females across indoor and outdoor settings were greater for the dimensions of complexity, color, texture, and lighting. On the other hand, males showed a greater preference for large-size settings. The results of the testing in regard to multidimensional shapes and more detailed use of scenic arrangements were so significant for the females in the study that an important question was raised pertaining to the possible influence of socialization practices and related opportunities presented to males versus females regarding environmental exploration and its influence on children's later environmental cognitions.

Past studies (Cohen & Trostle, 1990) have explored the fact that during the first ten years of children's lives, the educational and parental socialization practices encourage and favor boys' expansion of spatial awareness and knowledge, while simultaneously restricting girls' spatial development.

Cotterell

In 1984, Cotterell conducted a study to assess the anxiety of students in open space classrooms and to ascertain if this stress is greater than that experienced by students in conventional classrooms. The research included 142 students from four suburban high schools. Two of the schools were an open plan design, and two were conventional designs. The two open schools were identical in design and very different in architectural form from the traditional

schools. The two conventional design high schools were similar to each other and representative of most public high schools.

The classrooms in the conventional schools were rectangular in shape, located in close proximity to one another in regular alignments, and self-contained, linked to one another by external corridors. Traditional furniture was used in the rooms. The open plan schools contained classrooms designed for accommodating seven classes, with self-contained science laboratories and science classrooms. There were "withdraw rooms," where students could go to take tests or to study quietly. All classrooms had high vaulted ceilings, carpeted floors, and movable desks and chairs. There were many windows, and some classrooms bordered on courtyards.

Measurement of student personality was made by the Paragraph Completion Method. For one week, students were encouraged to keep a daily record of their experiences that pertained to events which generated uncertainty. Classroom observations were conducted in the fifth week of school in three classrooms at each school. Each week for a period of one month, targeted students were observed in the classroom. Interdependency among the activity structure of the lesson and student and teacher behavior was measured. Insights into the effects of differences in the classroom design of the open plan versus conventional high schools that could be related to the findings of the diary phase were sought.

Students in the open plan schools scored lower on "normalessness" (p. 468) and higher on school work anxiety. (The researchers described the normalessness as students exhibiting more off-task behaviors and prolonged transitions to new activities.) These students experienced less anxiety about locating classrooms, teachers, and classmates, but they were more anxious about performing competently in front of others, regardless of personality. Teachers in the open plan classrooms were less likely to use creative lesson plans that took advantage of the new settings.

Open plan classrooms had higher levels of off-task behavior and higher levels of peer-related interactions. The students in the open classrooms also needed more teacher direction during transition from one subject or activity to another.

In summary, students experienced more anxiety in the open plan school, and there appeared to be a mismatch between the learning environments and the needs of the students and teachers using them. The open space classrooms at the high school level did not seem to be a more flexible learning environment, and there was more off-task behavior.

Heubach

Heubach (1985) examined the effects of the physical learning environment and student behavior on the evaluated appropriateness of student privacy situations. The study addressed a necessary step in the development of privacy theory: the linking of environmental and behavioral analysis of privacy.

Forty-eight eighth grade students attending a middle school evaluated appropriateness for those situations with congruent levels of locational privacy opportunity and behavioral privacy requirements versus those situations with incongruent levels of locational privacy opportunity and behavioral privacy requirements.

A four-coordinate grid was constructed that identified locations theoretically offering high or low levels of privacy in the school. Students then completed a questionnaire in which they evaluated the appropriateness of performing various behaviors in each setting (library, restroom, cafeteria, hallways, and classroom). An analysis of variance with repeated measures was used to assess the participants' reactions to the appropriateness of situations in which setting, location, and behaviors were varied. After the results were analyzed statistically, the hypothesis was rejected.

The hypothesis anticipated a location-behavior effect regardless of setting. This was not shown by the study. Areas of perceived privacy such as the library, or areas with perceived lack of privacy such as hallways or the cafeteria, elicited the same behaviors from students. Students adopted a consistent behavior appropriateness hierarchy that was applied to all settings except the restroom. Implications from this study may be that educators should consider classrooms in which the seating can be varied to meet moderate privacy needs. Even though a student is not exhibiting a behavior that requires privacy, students are not comfortable being in perceived low privacy areas.

Hood-Smith and Leffingwell

This study was conducted with the assumption that the physical seating arrangement of the classroom would affect the behavior of students. The authors addressed the issue of how to change classroom design in an effort to eliminate the seventy percent of classroom time which the teacher spends at the front of the room.

The study began with thirty students in the traditional four-wall rectangular classroom which has desks in rows facing the teacher's desk. The back of the room was open to the hallway and to both visual and verbal contact with students from the adjoining classroom. There were no windows and only one entrance. In this situation, students were disruptive. They would leave class without permission, and the back of the room was inaccessible to the teacher. The noise levels were extremely high, and the maximum attention span of the students was three minutes during a lecture.

The second setting called for the rearrangement of furniture; the teacher's desk was placed directly adjacent to the doorway of the classroom. Student desks lined each wall and faced each other in rows of two, with one row on either side along the length of the room.

Although the study was not quantitative and somewhat limited in nature, the results showed that the teacher felt more control of the classroom, more comfort was expressed by the students at the availability of personal space, and each member of the class was able to interact with the teacher on a personal

level. This case study seemed to indicate that when physical walls are not available, students need the security of psychological walls. The security of a planned, ordered environment permitted control over the student's environment, reduced anxiety, and increased teacher availability. Tension, anxiety, and stress were reduced as a result of an alteration to the physical space.

Javor

Javor (1986) studied twenty-nine boys and thirty-two girls who left an open space school in June and returned to a closed classroom in the fall. An analysis of student achievement in the open space environment versus student achievement in the closed classroom formed the topic of the research. Two classes of tenth grade Honors Biology I were involved in the study, where one class was in an open classroom and one returned to a closed classroom. The teacher and the curriculum were the same for each class. Student grades were compared on a pretest given the first week of school, and student averages were compared for the first six weeks grading period.

Student achievement was assessed using the t-test. The results showed no significant difference between the pretest scores of the two classes. The final six-week averages for Class A and Class B were assessed using the t-test, and no significant differences between the averages of the two classes were obtained.

Based on the results of this research, it was concluded that there was no significant relationship between student achievement and building design.

Students in the closed classroom did not exhibit better proficiency on the prerequisite test, nor did they display a better acquisition of subject knowledge for the first six weeks. Javor believed this result may have indicated that the individual teacher is a more critical factor in student learning than is any measurable physical factor. This occurred, as the teachers perceived the open classroom to have more outside interruption, more discipline problems, and a greater noise level than the closed classrooms.

Javor suggested that this study was limited by the number of students involved. Other factors that may have influenced the search were class size, the effects of classroom temperature, and additional physical elements.

Jue

Jue (1990) believed that effects of school settings on students can best be understood from an interactionist perspective that considers the joint influence of individual differences and physical design factors. He used 136 randomly selected students and assigned the students to one of two interview groups. Students in the first group were given individual interviews; students in the second group were clustered by classroom and questioned together.

The interviews were preceded by unobtrusive observations of the target students within their respective classrooms. All student interviews and observations were made by a team of fourteen trained researchers. Data were collected by student interviews, behavioral observations, teacher questionnaires, and detailed surveys of the physical classroom setting. Cronbach's alpha was

used to measure the level of reliability of the interview questions and the CAS. Form B of the Minnesota School Affect Assessment was used to measure cooperative and competitive attitudes. A second questionnaire was administered to assess the socioecological characteristics of the various classroom settings.

Behaviors were observed and identified that may be indicative of adaptive responses to stressors in the classroom: student questions to the teacher, fidget/movement, translocation, task attention, and disruption. The researcher indicated that openness of the classroom perimeter explained a significant proportion of the variance in absenteeism, task inattention, and fidgeting, but was only highly significant as a predictor of fidgeting or restlessness.

Personality Type A students' absenteeism decreased as the amount of wall space defining the classroom decreased. The presence of discrete areas where students could work away from the rest of the class was associated with high levels of inattentiveness in extreme Type A students and low levels of inattentiveness in extreme Type B students. The availability of secluded study space seemed to have a more pronounced effect on Type A students.

Past studies have examined the main effects of environmental conditions on learning or behavior in children. This study went further in that personality types were studied, too. Because this study offers a more in-depth approach, the interaction of the person and the environmental variables have more explanatory power.

Kaufman

This study (1984) was the outcome of an extensive effort of tapes, interviews, and 1,200 pages of data of observation notes. The data were coded and reorganized into data books, and a book was prepared for each child. The participating elementary school served K-6 in a suburban area of middle class families.

The study used naturalistic research methodology. Observations were made twice weekly for two to four hours per day in third grade classrooms of the selected school. The field notes were summarized, and certain children were identified to participate in an additional thirty hours of observation. On the basis of these additional observations and informal interviews, a list of seven children were identified for reasons of seemingly social isolation, low task orientation, and distraction on academic work.

Observations began in the classroom with the seven students; the children's current and former teachers, an athletic coach, the school counselor, the school nurse, the parents, and the children in the study were interviewed.

Not providing adequate physical space and private areas proved to be stressful for the students in the study. The researcher concluded that practitioners need to make more allowances for human variation in the classroom. Kaufman stated that educators ought to look deeply into the lives of children to deduct the design elements that contribute to stress in students.

Krawitz

This study by Krawitz (1987) should be very interesting to growth areas that must support a large number of portable classrooms. Krawitz attempted to assess if these classrooms or their structure had a direct effect on student achievement.

The Purdue Teacher Opinionnaire was administered to a stratified random sample of teachers occupying classrooms in the three treatment areas of portable, temporary, and permanent classrooms. Each treatment group's data was analyzed using ANOVA.

Members of both the experimental and control groups were randomly selected to avoid bias and confounding variables. The mean, standard deviation, and variance for each treatment group on the composite scores of the Iowa and the Kansas Minimum Competency Test were calculated. To minimize the influence of confounding variables operating on the dependent variable, ANOVA was used. Fourth grade students were selected for the sampling.

No convincing evidence, as measured by standardized tests, was found to suggest that permanent, portable, or temporary facilities have a differential or injurious effect on student achievement. However, Krawitz suggested more research was needed because of the small sample of students.

Mwamwenda and Mwamwenda

The researchers hypothesized that the quality of education as reflected in academic achievement cannot be divorced from school facilities such as classrooms, furniture, and reading materials.

A questionnaire was administered individually to head teachers (principals). The questionnaire solicited information regarding the availability of school facilities such as classrooms, books, desks, chairs, staff rooms, and other facilities. This study was concerned with 2,559 students from Botswana who sat for the Standard 7 examinations at the end of 1984. The marks for participants were collected from the Examinations Section, and the marks in English, mathematics, science, and social studies were recorded for analysis.

The performance of students who attended schools with sufficient classrooms was better than that of students who went to schools with insufficient classrooms. Students who had access to desks and seats had much better overall performance, as well as improved scores in each one of the examined subjects. In summary, this research in a third world country supports the argument that school facilities were important to academic achievement.

Nash

Planned use of space will discourage or promote specific learning activities was the hypothesis of the Nash (1981) study. Programs and children in nineteen randomly (R) arranged classrooms and nineteen spatially planned (S)

classrooms were monitored during a three-year period. Over 250 four-year-olds and 250 five-year-olds were observed during this cumulative study.

The proximity of learning centers with similar objectives for the development of skills or concepts indicated to the children that they were permitted to transfer skills. Physical separation of activities provided the opposite message for the students. The investigation strongly suggested that the arrangement of classroom space enhanced or reduced specific learning outcomes. The planned spatial arrangement enhanced the observed learning outcomes, but did so mainly by removing impediments to learning.

The settings not given to harmonizing space with outcomes were no less powerful in producing learning, but the learnings produced were not intended by the teacher. Settings planned using criteria other than the advancement of student learning often produced distractive behavior, and made it difficult for a child to complete a task without interruption, or unlikely that the student would progress to more complex activities.

Navarro

Special education programs functioned as the driving force of Navarro's (1982) research. The study was an investigation of what factors account for the success, or lack of success, for certain special programs. It was hypothesized that there would be no significant relationship between the rating of student achievement and that of a physical facility, including room decor, design, and location. One of the independent variables was the facility, while the dependent variable was achievement.

Information pertaining to the independent variables was obtained via a mailed questionnaire which was sent to all elementary, school based, special education programs for emotionally impaired students in a division in Michigan. Achievement information was obtained from the Individual Educational Planning Committee report and the Peabody Individual Achievement Test.

A multiple regression analysis was performed to determine the relationship of the two variables. The Pearson product-moment technique was used to test the results. These did indicate a significant relationship between the facility and achievement. But, having a well-designed facility for emotionally impaired students does not, in and of itself, bring about higher levels of achievement in the special classroom.

Even though there were 290 students participating in the study, Navarro suggested that a larger sample size over a larger geographic area would have added to the value of the study.

Neill and Denham

The null hypothesis in this study was that the design of the classroom would have no influence on the behavior of pre-school students. Pre-school students between three and five years old in five pre-school units in Scotland were the participants. This University of Warwick and Queens College project also included staff who taught in the nursery schools and day nurseries.

All units studied were situated in a large industrial conurbation in west central Scotland and maintained by the local authority. Units were selected to give a comparison of three types of buildings: two old buildings; two open, airy buildings of the 1960's design, with high ceilinged rectangular playrooms; and, one 1970's open-plan design, with low ceilinged, irregularly shaped playrooms.

Twenty "established" children were the subjects of the main observations. Multiple regression analysis was used with three building design indices as the independent variables which were introduced into the analysis first. The three design indices included: a measure of play room openness that incorporated any petitions of above head height, an index of space per child, and an index of room group size. The three designs were intended to differentiate the social experience of children in units where all children had free access to each other and in units where much time was spent in separate groups.

All permanent professional members of the staff were interviewed. In addition, the staff completed a set of rating scales, and together, these covered staff observations and behavior within the pre-school unit. Their opinions and

preferences with regard to internal layout and building design were obtained. Staff responses were categorized and analyzed by means of non-parametric statistics.

Generally, the children spent their time in less educationally valuable ways in the more open units. The students seemed to have a lower span of attention and spent more time watching, wandering around, and doing nothing in the open-space classrooms.

The teachers felt that open plan spaces led to increased running, high-level motor activity, and rough-and-tumble. A potent factor was noise; the more open units were often extremely noisy. The noise level created difficulties in controlling aggression.

There was a high correlation between aggressive behavior and building openness. Disruption (rule-breaking) behavior was related to space. The observations indicated that staff-child interaction was more apt to be initiated by the staff in the less open units; in the more open units, the children made a greater effort to seek out the staff.

The researchers believed that there was evidence from this and other experimental studies to suggest that on days when a play room was screened into small areas, staff showed more educationally oriented behavior than on days when it was not. Their research indicated that opening up existing rooms may actually be counter-productive to the learning process.

Peatross and Peponis

These researchers examined the question of whether the layout and use of architectural space played a role as a pedagogical device by impacting social interaction and discourse in educational institutions. The formulation of the question was illustrated by two instructional case studies. This study was conducted with students and teachers as they interacted and reacted to space in two colleges. Observations were made in the art department of one school and in the school of architecture in the other.

The findings indicated that space not only reflects the educational system, but also affects the spatial pattern of socialization in such a way that pedagogical codes may be shifted. Attempts were noted of students trying to segregate themselves from others. The creation of buffer zones between the main circulation zone in the school of architecture and the bays was the clearest evidence of this. Lockers and screens were carefully placed by students to create further visual barriers between the internal circulation and the studio, or even between individual desks and sections of the studio.

The researchers concluded that spatial layout and space used in educational environment must be considered not only as reflections of the underlying pedagogical code, but also as independent variables which generate their own effect on pedagogy and its output.

The making of boundaries appeared to be inseparable from the defining of relationships. While the fundamental logic of the educational code arises from

the strength of boundaries, the fundamental logic of educational space develops instead from the complimentarity of spatial differentiation and spatial integration.

Shea

Shea (1983) researched the relationships between selected instructional environments and learning style preferences for certain elements of design. The Learning Style Inventory was administered to 410 ninth graders in a junior high school in New York to determine each student's preference for design. Those students exhibiting a strong preference for design were screened for IQ. Those with IQ scores within the 85-115 range were included in the study. A total of thirty-two ninth grade students ultimately comprised the sample population for this study.

Those in the sample population who preferred a formal design and those who preferred an informal design were assigned randomly and equally to one of the two experimental groups. Experimental Group A was tested in a formal design environment containing wooden and steel chairs and desks. Experimental Group B was tested in an informal design comprised exclusively of upholstered chairs and sofas, pillows, and carpeting. Performance was assessed through the scores obtained on the Metropolitan Achievement Test, Reading Comprehension Subtest. A 2 x 2 ANOVA was used to analyze the data for the main effects of design preference, instructional environment, and the interaction effect between the two.

The study indicated that differences occurred between the mean reading comprehension scores when students with diagnosed strong preferences for the learning style element of design were matched or mismatched with instructional settings that complimented their preferences (.001 level). However, the data showed that formal referenced students were able to adapt the informal environment to their particular individual needs for posture and comfort without detriment to their achievement. However, the mean reading scores of those students who preferred an informal design when taught and tested in a matched and then mismatched setting substantially demonstrated the handicaps to which informal preferenced students were subjected to on a daily basis.

Shea recommended further research, but concluded that the data indicated that knowledge and understanding of the design needs of students allowed administrators to cope more effectively and sensitively with problems such as absenteeism, tardiness, high mobility, restlessness, and poor discipline in classes in which mismatched design preferences may contribute to those behaviors.

Sommer and Olsen

These researchers (1980) were also investigating the concept of a softer classroom. They wanted to know if a softer classroom would increase student participation and increase the requests for use of the facility. This was a study that took place on a small college campus.

A letter was sent out to 100 faculty members asking two questions: (1) Would you favor some alternative to the present decor and layout of classrooms? (2) Would you specifically request to use an alternative classroom if it were available? From this survey, a classroom was developed with softer lights, pillows instead of chairs, writing boards instead of desks, and a circular room arrangement. Various decorative items were put in place, and the floor was carpeted. When the room was opened for class, observers were placed to monitor reactions and comments of students. Writing pads were left, also, in the room for students to comment.

All comments about the room were very positive. Records were made of participation in ten separate classes. Overall, 79 percent of the students participated voluntarily in the class discussions at some time during the hour. Students averaged more voluntary comments to the instructor and other students. Students felt free to change their positions within the room.

Although the intent of this research was valid, the study did not provide statistical data that showed any significance between the soft classroom and the regular lecture hall at a college.

Stires

Stires (1980) worked with the premise that seating position had a determinative effect on grades and liking for the teacher. To ascertain if this were true, Stires hypothesized that students who were randomly assigned to

seats in one class would perform as well as students who were permitted to choose their own seats in another section of the same class.

A coin was tossed to decide which class would be the choice condition and which would be the no-choice condition. In the no-choice condition, students were told at the first class meeting that they would be seated alphabetically at the second meeting. The students remained in these seats for the remainder of the semester. Any students who did not sit in their chosen or assigned seats were reminded to do so by the graduate assistants.

The 279 students in the college study took six 50-item multiple-choice exams over the course of the semester for a total of 300 possible points. Students completed two personality tests, and all students were permitted to earn up to 12 points of extra credit by writing reviews.

All the dependent variables in the study were analyzed using a 2 x 2 x 2 analysis of variance. There was a significant main effect of choice on test scores, indicating that the students in the choice condition scored higher than the students in the no-choice condition. There was also a main effect of the middle-side variable. Students who were seated in the middle scored higher on the tests than students seated at the sides. The front-back variable was not significant.

The only variable to have a significant effect on attitudes toward the course and the instructors was the middle-side variable. Students in the back

were absent more often than students in the front. Students at the front accumulated significantly more extra credit points.

The evidence favored the environmental hypothesis that students performed better because of their placement, not because they choose to sit in a particular place. Stires had not expected that the choice condition would get higher grades than students in the no-choice condition. It should be noted that when the students in the back of the room in the no-choice groups were told of the study, they protested that they had been treated unfairly.

Stueck

The major hypothesis was that children who learned in an environment designed to elicit and reinforce their development would enjoy school more and be more successful than children who learned in an environment designed with other criteria. Testing this hypothesis using the principles of educational criticism required a rendering of each situation and an analysis of the cases. Validity was based on a correlation between observed reality and the written word.

Elementary students in approximately a dozen schools across the nation were included in this twelve-year study. The researcher studied the aspects of the educational structure. The findings of this study were nebulous, as the methodology used to quantify the results were not reliable. Stueck (1991) designed a matrix that was used to assess and unify the aspects of physical, psychological, spiritual, and social elements of a facility. From these matrices

the researcher developed several principles; however, they were not developed through generally accepted research practices.

Talton

Talton (1983) stated that the purpose of this study was to examine the relationship between classroom environment and attitudes of tenth-grade biology students toward science and achievement in science. Simpson and Troost was the instrument used to measure the attitudes of the adolescents toward science. The subscales from this assessment dealt with the classroom environment. They included climate, curriculum, physical environment, the teacher, other students, and friends.

Fifteen parent volunteers were used to aid in data collection. Pearson product-moment correlations were calculated to examine the relationships among the components of classroom environment, students' attitudes toward science, and student achievement in science. Multiple linear regressions were performed using the Statistical Analysis System GLM, STEPWISE, and RSQUARE procedures. Instruments were administered at three times during the school year. Student achievement in science was measure by teacher reported semester grades.

Approximately 1,560 students were present throughout the year of data collections. The data collected from these students indicated that classroom environment predicted between 56 and 61 percent of the variance in attitudes toward science. Student attitudes toward the classroom environment predicted between 5 to 14 percent of the variance in achievement in science. Data

analyses using Lisrel V indicated a possible causal relationship between attitudes toward classroom environment and attitudes toward science.

Since examples of the open-ended questions dealing with the physical environment were, "I consider our science classroom attractive and comfortable," or "Our science classroom contains a lot of interesting equipment," one might conclude that the physical environment may have affected attitudes and achievement in science for the students in this study.

Climate Conditions

Often after a particularly challenging day with student discipline, an administrator will ask, "Is there a full moon?"; thus, insinuating that the changing of the tides has an effect on behavior. Scagliotta (1980) noted "numerous facetious and quaint remarks about weather change as a possible cause for maladaptive behavior" (p. 607) of students.

The extremes of atmospheric conditions are known: the reduction of pressure in high altitudes that causes nosebleeds, shortness of breath, and pounding temples. What has not been adequately researched is whether these and other atmospheric conditions such as heat, cold, and moisture affect student learning or behaviors. The following will seek through the available research to discover if climate conditions are a viable determinant to the variables of achievement and behavior, positively affecting these variables, or are a neutral influence.

Cash

As noted earlier in this synthesis, Cash (1993) conducted a study that examined the relationship between the condition of school facilities and the dependent variables of student achievement and behavior. She assessed this by working with small, rural high schools in the State of Virginia. Using the Commonwealth Assessment of Physical Environment to evaluate the secondary facilities and the Test of Academic Proficiency for grade eleven achievement assessment, this researcher was able to develop a model which addressed the

relationship between the facility and the variables of student achievement and behavior.

Cash considered heat conditions and air conditioning in her survey of the schools in the study. The reported mean scale scores for uneven heat or being unable to control the heat in each room indicated no pattern.

The indications for air conditioning were more predictable. As the air-conditioning level or quality of the climate control increased, the mean scale scores also increased. This researcher reported that "the difference between the lowest and highest condition mean scale scores was five points, which translated into eight percentile ranks" (p. 65).

The influence on student behavior was a positive correlation: as building condition improved, climate control being a part of that measurement, student disciplinary incidents increased.

Chan

Cash's results in the area of the physical environment of the school supported Chan's (1980) findings. Chan hypothesized that there would be no significant difference between the academic achievement of students in an air-conditioned environment when compared with the academic achievement of students in a non-air-conditioned environment.

As stated earlier in this synthesis, the data were obtained from the results of eighth graders in the State of Georgia taking the Iowa Test of Basic Skills (ITBS), and from a questionnaire completed by building administrators.

After statistically controlling for the effects of socioeconomic status, the vocabulary scores on the ITBS in air-conditioned schools were significantly higher than the vocabulary scores of the students in non-air-conditioned schools (.05 level of significance). There were no significant findings in the reading, language, work-study, and mathematics sections. However, there was a consistent pattern of higher achievement in air-conditioned schools. In fact, Chan's research indicated that air conditioning had a greater influence on student achievement than other physical elements.

Earthman, Cash, Van Berkum

This study (1995) replicated Cash's (1993) earlier study; both of them have been addressed previously in this synthesis. When comparing the total battery scale score means on the Comprehensive Test of Basic Skills for eleventh grade students in the
State of North Dakota, heat and air conditioning were both on the survey instruments completed by building administrators.

Schools with substandard heating rated 4.4 points lower on the CTBS than schools rated as above standard with regard to uneven heating and heating controls in the classroom. The results were not the same when observing air-conditioned schools. Substandard schools had scale score means of 805.6, while the schools rated above standard on the items dealing with air conditioning had scale score means of 798.0.

The results with student behavior, again, were not what was expected. As in Cash's research, as building condition improved, student disciplinary incidents increased.

Hines

Hines (1996) conducted a third replication of Cash's study; however, his research was with urban high schools in Virginia. Once again, the variables were the school facility, student behavior, and student achievement.

Principals or their designees were questioned as to their classrooms having individual heat control. Schools having more control over heating in the classroom scored lower than those schools without individualized control.

The results were quite different with air ccnditioning. The mean test score for schools reporting no air conditioning was 194.87. The mean test score for schools with air conditioning was 197.66, nearly three points higher.

Kaufman

In this study, Kaufman (1984) purposed to generate a theory related to stressors in the lives of students who were identified as maladapting. There were two main focal categories upon which efforts were concentrated during data collection: the home environment and the classroom environment. Kaufman stated that within these categories were "theoretical propositions" or stressors (p. 246) which comprised the heart of these categories Classroom stressors included the effects of noise, teacher correction of a child's behavior,

pressure to perform, peer correction of classwork, and other issues pertinent to the emotional climate of the classroom.

One of the stressors was excessively hot external temperature and humidity in a classroom. Using her methods of research, as described earlier in this synthesis, Kaufman believed that this condition related to a child's ability to learn and retain information. She also believed that such temperature conditions affected the emotional climate of the place where children learn.

The conclusions that the researcher drew from this study focused on the importance of studying children in depth when analyzing the construct of stress. Kaufman stated that educators need to look deeply into the lives of children to sensitize the elements that contribute to stress in students.

Knight

In 1990, Knight conducted a quasi-experimental investigation with 158 second graders in Alabama. The goal was to devise a practical, easily implemented, relatively inexpensive learning style model which accommodated students' learning styles in the areas of sound, light, temperature, design, and mobility.

Students were assigned to sections on a random basis with an equal distribution of students in each section. Within each school, two classes were randomly assigned to experimental and control groups. The students in the experimental groups were administered the Learning Style Inventory-Primary by a counselor within the school division. After the inventories were scored, a list

was devised for the teachers of students in the experimental groups, indicating preferences for the areas of sound, light, temperature, design, and mobility of the students on the teacher's class roster.

Teachers in the experimental classrooms were instructed to permit students to move to preferred areas of the room while doing seatwork in reading, math, and language. For example, students preferring sound were fitted with headphones; those preferring warmth were seated in warmer areas of the room; or, students preferring mobility were allowed to take walks in the classroom. Measures of light and temperature were made to make the experimental conditions as accurate as possible.

Students and teachers in the control groups were provided no special instructions. Teachers were informed that they were to continue teaching just as they normally did.

Then, a 2 x 2 x 2 ANOVA was conducted to determine the effects of the treatment and the interactive effects of treatment condition and sex and/or race on the post-test grades earned in reading, math, and language. There was no significance found for any of the interaction combinations of treatment groups by sex or race.

Although there was an initial test conducted to evaluate group equivalence and no significant pretest differences between the groups on grades in reading, mathematics, and language were found, the findings indicated a significant main effect for treatment groups for two of the three dependent

variables: language and mathematics. The control groups scored significantly higher.

The researcher suggested several reasons for the control groups' higher scores: (1) the accommodations of the learning environment which involved moving students around for lighter, darker, cooler, warmer, noisier, or quieter work areas may have been disruptive and negatively impacted student achievement; (2) the accommodations employed during instruction were too brief to generate a significant impact on student performances; and, (3) the model was of questionable value.

Murrain

The purpose of this research was to investigate the relationships among the temperature of the classroom, diagnosed individual preferences for either a cool or warm learning environment, and word recognition scores of students. Murrain (1983) used 268 randomly assigned seventh grade students from a suburban junior high school as participants in the study.

The Learning Style Inventory (LSI) was administered to the participants. Based on the results of the inventory, preferences for classroom temperature were identified. Scores of 60 to 69 represented a preference for warmth; scores from 70 to 80 were considered extreme. Scores between 31 and 40 were considered preferences for cool temperatures, with scores between 20 and 30 being extreme.

Subjects were assigned randomly and equally to two treatment conditions, a warm room and a cool room. All subjects were tested twice, once in a room matching their thermal preference and once in a room incongruent with their preference. Identical procedures were followed in each setting when the word test was administered. A 2 x 2 analysis of variance compared word recognition scores in each environment.

The LSI results revealed no strong preferences for thermal conditions. However, students who evidenced any temperature inclinations had significantly (.10) higher levels of achievement when in a preferred thermal environment rather than a setting that was incongruent with their diagnosed learning style. Murrain believed data from this study suggested that temperature, even though few participants demonstrated extreme preferences, may be of marked importance to individual students for whom it is an extreme preference. Ninety percent of the seventh graders in this study either preferred a warm setting or, based upon the scores of the sampled population, would evidence higher academic scores when taught in a warm instructional environment rather than a cool one.

Scagliotta

Scagliotta (1980) conducted a study with the premise that barometric pressure would affect student behavior. While conducting the research, 127 all-male children between the ages of nine and thirteen were observed. The participants had varied IQ's and were selected based on school-reported

histories of hyperactivity, irritability, preservation, distractibility, impulsivity, or other adversive behavior disturbances.

In order to delimit the variables associated with the disturbance types, specific behavior responses were identified to observe and record. A charting system was contrived for recording purposes.

Each day one-half hour before the designated times for charting, the assigned observer-recorder noted the air pressure and marked it on each child's chart. Each classroom teacher was aware of the purpose of the undertaking; however, daily readings of barometric pressure were not revealed to the teachers.

It soon became obvious that there were changes in behavior associated with different pressures. However, in order not to influence classroom teacher response, these clearly observable changes were not shared with the teacher until the conclusion of the monthly chart. Though the results appeared relative, they were inconclusive. In a day-school program, the barometric pressure differences during a 24-hour day and from one day to another, could not be taken into consideration.

Though decreasing atmospheric pressure is not the only condition predicting negative behavior, a definite relationship existed in the study between decreasing atmospheric pressure and maladaptive behavior in children. Once more, the author suggested further study.

Density

The variable most commonly connected with crowding is density (Duffy, 1992). This may include spatial density, the number of people per square feet of space, or, social density, the effects of the number of people in a space. The former can be calculated simply by dividing the number of people in an area by the total square footage. The latter is much more complicated. Duffy mentioned many studies concerning the effects of social density on human behavior. Some of these effects were reduced cooperative behavior, increased aggression, and a perceived lack of privacy.

River-Batiz and Marti (1995), from the Teachers College of Columbia University, found that overcrowding affected both students and teachers, in that they were deeply affected by the shortage of space and its consequences for learning. This finding by the researchers seemed to indicate that there may be a very intimate relationship between spatial and social density. Nearly a dozen studies that discuss this relationship have been identified.

Ahrentzen and Evans

This study was discussed previously with respect to classroom structure. The researchers (1984) also addressed elements that are related to density, especially in the area of privacy. They hypothesized that secluded study areas and individual desks were used by students to achieve solitude and were associated with heightened perceived privacy and greater satisfactions with the

classroom environment. They investigated how students changed their settings and activities to make the classroom more conducive to their needs.

There were sixty-five randomly selected students from thirteen classrooms in five elementary schools who were interviewed with open-ended and closed-ended questions. Some of the characteristics of the classrooms about which the students were questioned consisted of the ceiling height, square footage, square footage per person, cubic footage per person, and percentage of furniture occupying floor space.

Correlation matrices of the physical classroom characteristics were calculated to reduce redundancy. Surprisingly, classes with secluded study spaces ($p < .05$) and with individual desks ($p < .01$) were associated with less perceived privacy among students. The researchers thought that this unexpected finding may have been due to teachers in classrooms with secluded study spaces generally restricting student use of these spaces. "Our descriptive data reveal that when children want to be alone or to concentrate they prefer secluded study areas or corners of the room. Privacy . . . may have been too restricted, exclusively concentrating on the regulation of social interaction. Other aspects of privacy such as aural seclusion or visual shielding warrant further study" (p. 451).

Burgess and Fordyce

Burgess and Fordyce (1989) observed toddlers in spacious classrooms with six square meters of floor space per child, in large play areas outdoors, and

in divided classrooms that were identical to the open classrooms except that child height bookcases were arranged around the room as barriers. In devising their paradigm, these researchers drew from theories of spacing development having both biobehavioral and cognitive components.

As predicted, when students were given additional space, they altered their interpersonal distances, with or without classroom dividers. This study indicated that mild effects of density occurred within this age group in much less crowded environments than those used in studies of older children and crowding, even if the classrooms seemed very spacious to the adults in these situations.

Cash

Cash (1993) in her review of the literature, referenced studies that concluded that high social density adversely affected extended task performance and was recognized as a social stressor. When high and low density housing conditions at Auburn University were investigated, the research indicated that higher GPA's were found in the groups with lower density living conditions.

In her own study, however, the results were inconclusive. Students in facilities with 110 square feet per student had an associated mean scale score of 186. Students experiencing 110 to 145 square feet per student had an associated mean scale score of 193, but students with 145 square feet or more per student had an associated mean scale score of 189. Thus, the researcher concluded that there was no apparent pattern.

Cheng

This researcher from the Chinese University of Hong Kong found that effective classrooms had a physical environment that was perceived as being equipped with appropriate physical facilities: having enough space and being neat, clean, and free of pollution. Cheng (1994) developed an instrument of eleven items to assess the quality of the classroom physical environment as perceived by students.

The findings indicated students' perceptions of classroom environment are related to teachers' perceptions (Pearson's correlation coefficient = .486 in 171 schools). On the other hand, students' attitudes toward their teachers and the school shared a pattern of correlation with environmental measures, more so than any other affective measures. Students' self-efficacy of learning and attitudes toward peers shared the same pattern of correlation with perceived physical environment.

However, of the student affective measures that can be strongly predicted, perceived quality of physical environment seemed to be one of the strongest predictors among the measures of classroom environment. In Cheng's study, classroom space and the presence or lack of crowding were two elements that the students included in their assessment of physical environment. The findings illustrated a complicated relation between classroom environment and student affective performance.

Earthman, Cash, and Van Berkum

As stated earlier in this synthesis, the study by Earthman, Cash, and Van Berkum (1995) was very similar to the two studies by Cash (1993) and Hines (1996). Indeed, the researchers called it an "extension of the Cash research" (p. 16). In the work of Earthman, Cash, and Van Berkum, however, they conducted the research by including all 199 high schools in North Dakota. This State was selected because of its homogeneous population and its scores on standardized tests.

When comparing the density of sixty-seven high schools in North Dakota that were rated either substandard or above standard, those rated as substandard had a total battery scale score mean on the Comprehensive Test of Basic Skills of 800.5. The mean scale score for Grade 11 in above standard high schools was 805.8. This data may be indicative of a relationship between the gross space per student and the student's academic performance.

Hines

In his study about urban secondary schools, Hines (1996) used a questionnaire that school administrators completed about the condition of their facilities. One of the items on this questionnaire determined the student density in square feet per student. The gross square footage was computed and then compared to the individual school's population.

Substandard schools had less than 150 square feet per student and were associated with a mean scale score of 193.08. Schools rated as standard had

between 150 and 200 square feet per student, and had a score of 207.23. Above standard schools had over 200 square feet per student and an associated mean scale score of 199.50. No conclusion regarding density could be drawn from these data and its relationship to the dependent variables of student achievement and behavior.

Jue

This researcher hypothesized that density did not have a uniform effect on each student. Jue (1990) used the medical discipline's definition and behavioral characteristics of the Type A and Type B persons. The Type A person was characterized as manifesting extreme competitiveness and a strong sense of time urgency, impatience, easily-aroused anger, and aggression. The Type B person was noted by the absence of the above Type A characteristics.

When he conducted his research, the amount of space allowed per student ranged from twenty-three to sixty-four square feet, with an average of thirty-four square feet. Furniture occupied between seventeen and thirty-three percent of the floor space, with an average of twenty-five percent. Student work stations were arranged in rows in nine of the classrooms, while six classrooms were arranged in a cluster arrangement. One classroom used both rows and clusters of desks.

The findings indicated that density was a significant predictor of task inattention. In addition, the predicted interaction between coronary-prone behavior patterns and the quadratic component of destiny was significant for task

inattention and fidgeting. Jue stated, "In analyses of task inattention and fidgeting scores, the interactions across levels accounted for 37.2 percent and 32.2 percent of the total explained variance, respectively" (p. 74).

The curvilinear relation between classroom density and task inattention for Type A and Type B levels of coronary-prone behavior patterns showed a marked difference in the frequency of off-task behavior at the lower levels of classroom density. Type A students showed high inattentiveness and Type B students showed low inattentiveness. The same held true when fidgeting was observed. The marked feature of the data was that with Type B children, the highest levels of fidgeting occurred when the average square footage per student was centered within the density range of the sample.

Density, openness of perimeter, and secluded study space were found to contribute significantly to the explained variance in the scores for task inattention and fidgeting. However, Type B students were much less affected by density than Type A.

Peatross and Peponis

This study included students and teachers as they interacted with and reacted to space in two separate colleges. Observations were made in the art department of one and in the school of architecture in the other. Circulation and interaction were documented in these departments, and axial maps were drawn.

The spatial configuration of the art department gave the impression of disorder and complexity. There was an unpredictable distribution of departments

and offices, complex sequencing of rooms, and no logic to the placement of corridors. Although the department lacked any obvious gathering spaces for students, other than the lunchroom at one end of the building, the atmosphere in this department was one of liveliness, with students frequently seen interacting in a friendly manner.

The density of space use was higher in circulation spaces than in other spaces. Most importantly, there were more persons talking in circulation spaces than on the floor as a whole, and circulation spaces were characterized by intensive use and intensive interaction. The researchers (1995) found that, in spite of the seemingly haphazard spatial organization of the art department, it appeared that the syntax of space influenced the spatial pattern of socialization, thus providing some evidence of space acting as the independent variable. Departments seemed to work spatially as part of a coherent whole, rather than independent segments, even though there were walls and other types of boundaries that acted as separators.

The second set of observations took place in a school of architecture. This college was arranged around a central atrium. Studios, offices, and computer laboratories were arranged in a logical manner. The configuration and zoning of the building was clear. Teaching and socialization took place in the open plan studios, where the configuration was continuously altered as students rearranged desks, lockers, and storage cabinets.

In this school there was no bias toward using circulation spaces for interaction; however, interaction was more evenly diffused throughout the floor. When correlations between space use densities and integration were computed, there was no correlation between integration and the total presence of people, or between integration and the numbers of people talking. The only clear correlation was between spatial integration and the density of movement, as shown in the art department findings.

The art department and the architectural departments seemed different in terms of their space use. In the former there was clearly a dependency on the configuration. In the latter, only movement showed such a dependency. As was found in some of the previous studies on privacy, students at the college level continued to create shelters or boundaries to provide as much division as possible between circulation and their desks.

Peatross and Peponis argued that "in order to understand the role of space in an educational system, the configuration of building layouts must be considered not only as a dependent variable reflecting pedagogical principles, but also as an independent variable capable of generating its own pedagogical effects" (p. 366). These researchers found that the configuration of space can affect the spatial pattern of socialization and generate tensions, and even shift pedagogical practices. What they did not discover was a consensus of what architecture was. They hypothesized at the beginning of the study that the new, recently designed architectural department would provide a better learning

environment. However, the results of their observations in this study did not support that hypothesis. The researchers found that the making of space and boundaries is inseparable from the defining of relationships.

Rivera-Batiz and Marti

This research presented data showing that overcrowding in the New York City public schools has had negative effects on instruction and learning in the system. River-Batiz and Marti (1995) hypothesized that this would be particularly true in the areas of the city in which the proportion of students of low socioeconomic backgrounds was higher. Student achievement, student attitudes, and quality of life in the schools were the dependent variables.

First, data were collected from the school profiles of 184 middle school buildings, of which 28 percent were considered overcrowded, and 744 elementary school buildings, of which 56 percent were considered overcrowded. These data included information on socioeconomic status, achievement test scores, and other demographic items. The first set of data from the profiles of all schools was utilized to examine the linkages between overcrowding and student achievement through the use of multiple regression statistical analysis.

Secondly, a study was carried out of randomly selected overutilized schools (130 percent utilization rate). Their location was selected to reflect the diversity of the city. Students, teachers, and administrative staff were interviewed, facilities were visited and studied, and questionnaires were distributed to students and teachers. Opinions and perceptions of students and

teachers were sought of the learning environment within the schools and how overcrowding affected them. Student achievement of 599 third and sixth graders was the focus of the second part of the study.

Holding other variables constant, the proportion of sixth graders in overutilized facilities passing the minimum standard for the Degrees of Reading Power examination was between four to nine percentage points less than that in schools that were not overcrowded. The difference on the mathematics test was between two to six percentage points below that in schools that were not overutilized. However, the results were just the opposite in schools with comparatively high socioeconomic status.

The results suggested that, among schools with high proportions of poor students, overcrowding had a clearly defined negative impact on student achievement. For schools with students from families with higher socioeconomic status, the connection between overcrowding and achievement was dominated by the fact that schools with high academic achievement attracted more students and caused overcrowding. Thus, overcrowding was positively correlated with student achievement.

When attitudes were surveyed in the randomly selected overcrowded schools about the quality of life in those facilities, most felt that there were too many students in the classrooms, rather than thinking that the school or classrooms were too small. Forty percent believed that this caused problems concentrating and finding places to study quietly. Nearly half of the non-

graduating students surveyed did not want to remain in the school the next year. This occurred in spite of the fact that the majority responded that they had many friends in the school.

As in the case of the students, the 213 teachers in the overcrowded facilities reported being deeply disturbed by the situation. For teachers, overcrowding and lack of space were not as important as sanitation, the need for more personnel, maintenance, and violence. They felt strongly that overcrowding affected instruction and the quality of life in the school.

Noise

Construction, jet aircraft, sound systems, television, radio, automobiles, trucks, and many other elements bombard the airways with noise. Music rooms, gymnasiums, crowded hallways, cafeterias, and crowded classrooms comprise an environment of sound at school. How do all of these affect the student?

Duffy (1992) stated that "designing a physical environment for learning that promotes the ability to understand speech and suppress unwanted sound is a goal" (p. 81). This portion of the synthesis will review studies that have been completed on noise that can confuse and conceal spoken communication in a classroom, causing a problem to those students who are listening or attempting to concentrate.

Ahrentzen and Evans

The researchers (1984) stated a problem that included a hypothesis that there would be a restriction of class activities in the more open and

nonpermanent perimeter structured classrooms in order to prevent noise. An interviewer was used to collect the data necessary for the study. Sixty-five randomly selected students were interviewed from thirteen classrooms in five different schools.

The findings indicated that the percentage of structural walls was "only related to one distraction measure, aural distraction to loud sounds outside the classroom ($r = .51$, $p < .05$)" (p. 445). This noise affected student satisfaction with the classroom and satisfaction with reading in the classroom. Open perimeter space was not related to any distractions nor to satisfaction with tasks in the classroom. There was, however, a negative relationship to student satisfaction with the classroom.

It should be noted, as well, that this study indicated that teachers adjust their curricula to curtail possible distractions in open-spaced classrooms. This includes activities that may be deemed noisy.

Cash

In her study, Cash rated the acoustical environment by addressing the type of material used for interior ceilings. The first condition was related to wood or open beam construction, and two schools fell in this category with a mean scale score of 188. Condition two was facilities with plaster or acoustical tile in at least three-fourths of the instructional spaces and accounted for eighteen of the schools with a mean scale score of 188. Eighteen schools were in this category.

The third condition was the twenty schools that had acoustical tile throughout the instructional spaces. The mean score for these facilities was 189.

As the acoustical ceiling condition accounted for no more than one point of difference in the mean scale score, this finding was not conclusive.

Christie and Glickman

The purpose of this 1980 study was to examine in an experimental framework the effects of classroom noise on children's intellectual performance. A total of 156 elementary students from a school in central Ohio participated in the research. They included first, third, and fifth graders.

Half of the students were assigned to a noisy environment, while the other half worked on their tasks with minimal noise. All of the research took place in self-contained classrooms. A 2 x 2 x 2 factorial design was used, with the factors being noise present versus absent, male versus female, and grade levels. The students were assigned randomly, except for the constraint that males and female were selected to be equally represented at each grade level in each noise condition.

The intellectual task consisted of the Standard Progressive Matrices. To approximate classroom noise, fourth-grade children were tape-recorded, and the recordings were adjusted to meet the noisy (70dB) and quiet (40dB) conditions. The children were tested in the school library, so that the conditions were maintained consistently. If a child made two consecutive mistakes on a subtest,

the experimenter would begin the next subtest. Each child received a score consisting of the total number of correct responses.

With increased age, children's performances on the Standard Progressive Matrix improved. This result was predicted, as children can solve increasingly complex visual discrimination problems as they develop. For this finding, a conventional unequal n analysis of variance was used on the data, which was significant at the .001 level.

Children with increased age were not better able to ignore the distracting effects of the classroom noise. However, when noise manipulation interacted with gender, males tended to exhibit higher scores in a noisy environment, while females tended to perform higher in a quiet environment. There was a .05 level of significance.

There was evidence indicating that performance on the standard progressive matrices correlated with performances on various classroom activities. Therefore, it would be possible that students' performances on many tasks in the classroom will vary as a function of classroom noise levels. As noise levels do not affect the performance of all children in the same way, this study indicated that the noise levels in the classroom should be varied to fit optimal learning for the individual student.

Cohen, Evans, Krantz, and Stokols

These researchers (1980) conducted their study using three null hypotheses: (1) the blood pressure of students from noisy schools would not be

higher than that of students from quiet schools; (2) students from noisy schools would have no more feelings of helplessness than students from quiet schools; and, (3) the impacts of noise on attention strategies were no greater in noisy schools than in quiet schools. The independent variable of noise was that generated by aircraft in the air corridor of the Los Angeles International Airport.

Three cognitive tasks were administered to evaluate the students' feelings of personal control, and to determine whether the children employed common attention coping strategies. All 262 subjects were given hearing tests to determine that they had no hearing loss. Blood pressures of the participants were taken multiple times, and their heights and weights were measured. Absenteeism was used as an indirect measure of health.

Test scores were compared on all students. Regression techniques were used to compensate for differences between the noise and quiet samples on racial distribution and mobility. Sound levels were measured in all schools for one hour in the morning and one hour in the afternoon to ascertain the highest reading in both the noisy and quiet schools.

Each child was given a manipulative task that had been preceded by a success or failure experience. The researchers did this to examine the effect of noise on response to failure and on persistence with a difficult task. The time was recorded for the span from when a student began a task to when the student gave up on an insoluble problem.

For the distraction condition, students completed their work while a tape recording of a male voice reading a story at a moderate level of volume was played. Students were then given a task within a setting without distraction.

This study combined the naturalistic components of the effects of aircraft noise on students and laboratory effects of noise in a naturalistic setting. The results of the effects of noise on blood pressure were consistent with previous laboratory research. Children from noisy schools had higher blood pressures and were more likely to give up on a task than children from quiet schools.

Before the study was conducted, the researchers predicted that children would find coping skills to adjust to the noise with increased years of exposure. However, increased years of exposure to the aircraft noise made students become more distractible. The only evidence of an adaptation effect was that the systolic blood pressure differences stabilized with increased exposure.

The greatest differences between the noisy and quiet groups occurred during the first two years of exposure. Another somewhat surprising effect was that children who had a respite by living in a quiet neighborhood experienced the same impact of noise at school.

The findings did not support a link between noise and student achievement. Students in the study were in different schools and classrooms and had different teachers, so it may be likely that these factors added error variance to the equation, making the detection of the noise variable difficult.

Although noise-school children were shorter and weighed less than quiet-school children, neither of the differences were conclusive. Moreover, noise-school children had better attendance than their counterparts.

Children from the schools in the air corridor were more likely to fail to solve the treatment puzzles and were more likely not to persist. This result may indicate that they felt or acted as if they had less control over their outcomes.

In summary, conducting this study in combination with the laboratory noise, the data suggested a possible impact of air-craft noise on psychological adjustment and on nonauditory aspects of health.

Earthman, Cash, Van Berkum

When a comparison of the total test battery scale score means on the CTBS and the results of the State Assessment of Facilities in Education was made, ceiling condition was one of the items on which the students in the above standard facilities scored higher than students in the substandard schools. The difference was 4.2 means score points.

When the same comparison was made with noise in a facility, the opposite was true. Students scored 4.5 points higher in the substandard buildings. Thus, no significant conclusions could be made from this study concerning noise and student achievement.

Hines

Hines (1996) looked at acoustical tile on interior ceilings, as well as noise in the classroom. There was no statistical data to indicate that acoustical tile

made an improvement in composite scale score means on the Test of Academic Proficiency.

The same could be stated for classroom noise. In the first condition, in which noise was evident and no measure had been taken to reduce it, the mean scale score was 206.32. In the second condition, reduction measures had been taken and the score was 196.99. In the third condition, noise was no factor and the score was 196.42.

No conclusions could be drawn from these results.

Hyatt

This study questioned the effects of jet aircraft noise on achievement tests and attitudes of students in noise affected schools. The school district used in this study had a kindergarten through twelve program with an average enrollment of 18,622 students. The school division surrounds the Seattle-Tacoma International Airport, which processed over two hundred twenty flights per day during the time of the study. The schools selected for the research were those in Zone I (lowest level of noise) and Zone III (highest level of noise).

Hyatt (1982) used achievement test data from the regularly scheduled testing program of the school division. This program called for testing at grades two, four, six, nine, and eleven. For the years of the study, 6,340 students completed the battery of tests.

The noisy and quiet schools were demographically matched using ten factors to describe the immediate households of the students: professional or

technical workers, managers, or administrators; intact families; persons twenty-five or older having a high school diploma; living in the same house for five years; families not on public assistance or welfare; families with income above the poverty level; and, others.

Summaries of student achievement in noisy versus quiet schools were computed for significance using T-scores. The same was computed for the summary of student achievement in demographically matched noisy versus quiet schools.

The opinion questionnaire that was used was developed for a law suit against the Port of Seattle and was revised by a testing firm. A total of 1,014 students was surveyed at grades six, nine, and eleven. This questionnaire was intended to measure student attitudes toward the classroom environment in noisy versus quiet schools, and to discover if that attitude affected achievement.

The findings indicated that there was significantly (.01 level) greater achievement for grades two and four in the quiet schools. The level of significance for grade eleven was .05. There was no statistical relationship at grade six, and a negative relationship was derived at grade nine. When schools were demographically matched, student academic achievement was significantly higher in quiet schools at all levels except grade nine.

Students perceived the noisy schools to have noisier classrooms, to be more confusing, and to have more interference. Students said the teacher was

difficult to hear, the teacher needed to speak loudly, and the outside noise interfered with learning.

Students attending schools in Zone I scored higher on achievement tests than those attending schools in Zone III. The only exception was grade nine, which may have been due to a sound proofing project that was in progress at the time of the study.

It should be noted that, although the ninth grade was the only grade without a level of significance in the difference between test score means, the ninth grade perceived the greatest differences in their school environments. Along the same line of thought, students in the noisy schools with high achievement scores rated their classrooms as being more noisy that did students with low test scores. Students in the quiet schools had the opposite results.

Kaufman

The researcher hypothesized that there are certain situations in the classroom and in the home that create stress in children identified as potentially at risk or maladjusted. The study used naturalistic research methodology. Observations were made twice weekly for two to four hours per day in third grade classrooms of selected elementary schools in a suburban area of southwestern United States. This was done to provide initial observations for selection of the children for later participation.

Certain children were identified and observations continued in three third grade classrooms for another thirty hours. On the basis of these observations

and informal interviews with the children, a list of seven children was identified for characteristics such as social isolation, low task orientation, distraction on academic work, and noncompliance with teacher requests.

Contacts were made with parents of four of the seven children. They were selected to participate during the next school year; however, one student moved away during the summer. Thus, three students were used in the in-depth study. Observations began the next school year.

Kaufman (1984) identified noise as a stressor with the three children. Indeed, non-related, ambient classroom noise was observed to cause great stress.

The conclusions that the researcher drew from this study focused on the importance of studying children in depth when analyzing the construct of stress in children. Kaufman said that educators need to look deeply into the lives of children and make more allowances for human variation in classrooms.

Knight

This quasiexperimental investigation was reviewed earlier in the synthesis. There were 158 second graders who were assigned to sections on a random basis with an equal distribution of students in each section. Within each school, two classes were randomly assigned to experimental and control groups.

Inventories were conducted with the experimental groups to ascertain student preferences for sound, light, temperature, design, and mobility. Teachers were notified of these preferences. Teachers were also told that

students should perform reading, math, and language seatwork in preferred areas of the room.

As stated earlier, the experimental and control groups did not differ prior to the beginning of the treatment, but the control groups scored significantly higher in math and language. There was no significance found for any of the interaction combinations of treatment groups by gender or race.

Knight (1990) suggested further research, as this study was of short duration and employed a questionable model.

Pizzo

Pizzo (1981) investigated the relationship between two selected acoustic environments, quiet and noise, and students' diagnosed preferences for sound. The researcher expanded the question to include how this element affected achievement and attitudes of male and female sixth graders.

There were 125 students who were administered the Learning Style Inventory to determine their preferences for sound. From these results, two acoustic preference subgroups, one preferring quiet and the other sound, were formed. These groups were further delineated by gender, resulting in four subgroups. From this pool, sixteen male and female subjects, diagnosed as having learning style preferences for quiet, and sixteen male and female subjects, diagnosed as having learning style preferences for sound, were selected randomly.

This study employed a post-test-only control group design. The statistical analyses applied to the data obtained used three-way analyses of variance and t-test procedures for each of the dependent variables of reading, comprehension, and attitudes. Two acoustic environments were selected: the quiet being 40dB or less and the sound condition having 75dB or more.

The comprehension subtest of the Gates-MacGinitie Reading Tests was administered under the quiet condition or the sound. Following the 35-minute time period required for the subtest, the semantic differential scale was administered to the students in order to determine their attitudes when tested in an acoustic environment that was congruent/incongruent with their learning style preferences for sound.

No one acoustic environment facilitated conclusively higher mean reading comprehension or mean attitude scores. No significant differences were evidenced between students having a learning style preference for quiet and those having a preference for sound. There were no notable differences between male and female scores. However, there was a significant interaction between the acoustic environment and learning style preference with respect to mean reading comprehension and mean attitude scores. Students tested in an environment congruent with their preferences for sound or quiet achieved much higher mean reading comprehension and mean attitude scores than students tested in an incongruent acoustic environment.

The results support the conclusion that subjects tested in acoustic environments congruent with their preferences for sound achieved significantly higher achievement and attitude scores than their peers tested in incongruent environments. Further, preference was not based on gender in regard to the required acoustic environment to perform at the optimal academic levels.

Zentall and Shaw (first study)

Zentall and Shaw (1980) hypothesized that hyperactive children would not respond or perform any differently than the control group when employing (a) a familiar class task; (b) classroom noise selected to be high in linguistic content, administered at levels representative of actual classroom levels; and, (c) high and low noise conditions administered in a counterbalance order.

Twenty-four hyperactive students and twenty-four control students were selected from seven second-grade classrooms based on their hyperactivity scores on the Conners Abbreviated Teacher Rating Scale. Test groups of eight children (four hyperactive and four control) were drawn from two randomly selected classes per test day and were randomly assigned to a treatment session.

During the sessions, students were escorted from their classes to a small, pale green room which contained a teacher's desk and chair, a bookshelf and filing cabinet, and a circular table with eight small chairs for the children. After an adaptation period, an arithmetic task was introduced to the students, and the

exercise was timed. Correct responses were measured for use in the statistical data of this study.

Approximately two weeks later, low levels of noise were administered while these same students performed similar math problems. The remaining students received noise levels in the reverse order.

A three-way repeated-measures analysis of covariance, using achievement as the covariate, was performed on the activity and performance scores for the main effects of groups, treatment, time, and interactions were obtained. An ANCOVA was employed, even though the groups did not differ on IQ or achievement.

Zentall and Shaw concluded that hyperactive students were more active than control students overall; however, hyperactive children were more active in high noise environments and less active in the low noise setting than the control children, who exhibited the opposite pattern.

High-linguistic-noise appeared to have the greatest negative effect on hyperactive children. Both groups became more active during the second test session without a pursuant loss in performance.

Differences between groups consistently showed that the hyperactive students demonstrated greater activity and fewer correct problem solutions, even though there was an apparent equivalency between the groups in IQ and general achievement scores.

This study was not intended to exemplify an effect of the physical environment; however, its findings on noise in the classroom are important.

Zentall and Shaw (second study)

The purpose of the second experiment was to test the generality of classroom noise effects by presenting the noise in a more natural way, while children were performing repetitive tasks involving auditory memory processing. This study involved reading, rather than math skills, and an attempt to reduce social interaction.

Four new children were added to this sample so that each group had twenty children. Hyperactive and control children were randomly assigned to test groups, with the constraint that four hyperactive and four control children were tested at the same time. Groups of eight children were randomly assigned to a test day. A new recording of classroom noise was used. Sound-pressure-level reading varied little from desk to desk. Ambient sounds of chairs moving, whistling, laughing, desk tops slamming, howling, and background talking were included on the tape with distinct verbal behavior produced by children. The low level recordings were made during work time in the classroom.

The hyperactive children were significantly more active than controls and were observed off task more frequently than controls. There was a nonsignificant tendency for both groups to omit more letters and to make more total errors under high noise conditions. Control children exhibited more total errors in low noise, while the opposite was true for the hyperactive students.

There was some evidence to suggest that high levels of noise were less disruptive when encountered while performing familiar tasks rather than new. Classroom noise appeared to add to the challenge for the hyperactive child, especially when the task required some auditory processing of information.

Again, Zentall and Shaw (1980) were not conducting this research with the intent of assessing an element of the physical environment. Their conclusions were to attempt to find a better learning environment for the hyperactive child; however, the findings are applicable to this discussion of noise and its more general effects on student performance.

Lighting

What child has not had a parent or teacher admonish them for not reading with the correct amount of light? Often these warnings are accompanied with the comment that doing so is not healthy for the student's eyes.

In a 1963 report (Dunn, 1985), the U. S. National Society for the Prevention of Blindness reported that visual efficiency had a marked effect on many academic outcomes and that it was influenced by a number of factors. Some of these factors included the presence and amount of glare, the relative brightness of objects and their backgrounds, and other facility and environmental factors.

Dunn also reported that environmental lighting exerts profound biological effects on humans. He cited several studies that indicated that the lighting of a

school building should be considered a key element of the design and construction because of its influence on physical and mental health.

The following studies were identified as research that was conducted with lighting being the independent variable and student achievement or behavior the dependent variables. The research indicated that classroom lighting design plays a critical role in both dependent variables.

Cohen and Trostle

As described earlier in this synthesis, preference paradigms of physical characteristics such as size, shape, color, complexity, texture, and lighting were introduced to students through a story-walk. The students, seventy-eight kindergarten and first-grade children, selected the stimulus in each scenario that had the greatest personal appeal.

When the responses of the students were converted to quantitative scores, there were differences in the results for males and females. Mean scores for females were greater for the dimensions of color, texture, and lighting. It was observed that older students showed a stronger preference for more intense lighting effects in comparison with younger children's preferences.

For the younger children, correlations for the two categories of color and lighting were statistically moderate (color, $r = .69$; lighting, $r = .36$). Cohen and Trostle (1990) reported that "by the time children reach school age, their capacity to discriminate among different environmental setting chara[illegible]eristics and to selectively respond to those of preference is well developed" (pp. 762-763).

Chan (Artificial Lighting)

This study was conducted in 1980 and attempted to ascertain how the physical environment of the classroom affected the middle school student. The researcher stated that there were numerous studies involving elementary and secondary students, but studies involving students at the middle level were scarce.

There were several hypotheses tested in this study. However, the one most important to the variable light was that there would be a difference between the academic achievement of students in classrooms with fluorescent lighting when compared with the academic achievement of students without fluorescent lighting.

Although the methodology was discussed previously, it should be reiterated that the findings showed that achievement was higher in schools with fluorescent light. Even though the statistics were too small to be significant, in the main, there was evidence to indicate a tendency of better student achievement in a fluorescent lighting environment.

Grangaard (Artificial Lighting)

Grangaard (1995) attempted to replicate a study that Wohlfarth conducted in 1981 to determine the physiological and behavioral effects of color and light on elementary students. There were three phases in the study in which the color and light of the test field were manipulated.

As described with the variable color earlier in the synthesis, there were three two-day phases in which children were video-taped for fifteen minutes in the morning during the same activity and for the same period of time in the afternoon. The students' blood pressures were taken once in the morning and once in the afternoon. The researcher was very consistent in making sure the measurements were obtained at the same time each day.

Phase I consisted of an environment which included cool-white fluorescent fixtures. Phase II students were in a classroom in which the lights were a full-spectrum duro-test vita-light. Phase III was identical to Phase I.

Since color and light were the only known variables during the three phases, these were considered the reason for dramatically decreased blood pressures in the second phase. This phase also had greatly reduced off-task behaviors. The research demonstrated the fact that there was a cause/effect relationship between the child and the environment.

Hathaway, Hargreaves, Thompson, and Novitsky (Artificial Lighting)

These researchers undertook their study (1995; 1993; 1992) to replicate the findings of an earlier study which investigated the effects of classroom lighting on student achievement, health, and behavior and to test the differential effects of lighting types on students. Five study sites were selected that included a school with indirect high pressure sodium vapor lamps, a school with full spectrum fluorescent lamps, two schools with full spectrum fluorescent lamps with UV enhancement and fixtures that contained aluminum reflectors and

aluminum grid diffusers or open egg-crate diffusers, and a school with cool-white fluorescent lamps.

Data were collected on fourth grade students including age, sex, nutrition histories, fluorine levels, dental histories, attendance histories, general health, growth and development histories, scholastic achievement histories, skin types, and vision histories. The histories were compared with the data collected over a two-year period of the students' exposure to the five sites. There were no significant differences in the ages or daily nutrition of the students at the different sites, supporting the fact that the students at the five sites were quite comparable. Even the drinking water supplies were adjusted to have similar amounts of fluorine.

On the basis of an analysis of attendance records, full spectrum fluorescent light with UV enhancement did have an effect. The health and general development of the students were affected by this light. Conclusive differences were found to include age at the onset of menarche, height gains, weight gains, and gains in body fat. When comparing achievement records, the UV enhanced light had an effect on the rate of achievement.

On the basis of an analysis of vision records, light did not have an effect on changes in vision. However, there were indications that the rate of change in uncorrected vision at two of the sites was affected by the quality of lighting systems.

Ingraham (Artificial Lighting)

The electromagnetic radiation level has been proposed as one factor in the classroom environment which measurably impacts students' behaviors (Ingraham, 1983). To explore this hypothesis, Ingraham designated triads from three third grade classrooms. The students were chosen on the basis of those who exhibited the most hyperactive tendencies. The study was limited to twenty-one days: three days selecting classrooms and target students, six days of baseline data collection, and twelve days of light change and immediate collection of experimental data.

An electric timer affixed to a recorder board was used to provide time cues for recording target student off-task behavior. Each student's behavior was observed for periods of one minute, and every three seconds of the minute, the student's behavior was recorded.

A four category observation instrument was developed to note inattentive behavior, off-task behavior, disruptive behavior, and inappropriate location. Analysis of variance procedures and t-tests were used to determine the equivalence of classroom groups and student triad groups during the baseline observation period. These same statistical methods were used with uncorrelated means, calculating data collected during the experimental observation period. Analysis of covariance procedures were used to adjust the experimental period averages. Subsequently, for multiple pair-wise comparison, the Sheffe' procedure was employed.

The results indicted very little difference in total off-task behaviors per minute between baseline comparisons of the combined classrooms with full electromagnetic radiation and the classroom with no electromagnetic radiation. Therefore, direct comparison of experimental period behaviors between groups was warranted to determine the effects of initial baseline behavior patterns. The experimental classroom showed a reduction of total off-task behaviors per minute. This discovery supported the conclusion that reducing electromagnetic radiation from full spectrum lighting would reduce hyperactive student behavior in the classroom groups.

Results from the triad groups provided no evidence to indicate that reducing electromagnetic radiation from full spectrum fluorescent lighting would reduce off-task activities; however, the study did show that grounding and shielding electromagnetic radiation from full spectrum lighting would reduce hyperactive behavior in heterogeneous groups of students.

There was a possible cause-effect relationship between electromagnetic radiation and classroom students' off-task behaviors.

Knight (Artificial Lighting)

Knight (1990) hypothesized that altering the environment would have a positive effect upon students' grades in reading, mathematics, and language. He conducted his research with 158 second graders in an Alabama school division. After administering a learning style inventory, a list was devised for

each teacher indicating students' preferences for sound, light, temperature, and design.

In the experimental classrooms, students were permitted to move to preferred areas of the room while doing seatwork in reading, math, and language. For instance, those preferring bright light were seated in well-lighted areas.

The results were not as the researcher had expected. The control groups scored significantly higher grades in language and mathematics than participants in the experimental groups. There was no significance found for any of the interaction combinations of treatment groups by sex or race.

Krimsky (Artificial Lighting)

In order to determine the relationship between achievement and diagnosed learning style preference for light, Krimsky (1981) conducted an investigation to examine student performance in speed and accuracy on a selected reading test under extremely bright or dim conditions. Thirty-two fourth-grade students in Nassau County, New York, were selected for this research.

Student preference for either bright or dim light was discovered by administering the Learning Style Inventory (LSI) to the entire fourth grade prior to the experimental period. Equal numbers of students were randomly and equally assigned to one experimental group that had an extreme preference for bright light and another experimental group that had an extreme preference for dim light. The Gates-MacGinities Reading Test for Speed and Accuracy was

administered to both groups, and the Gossen Luna-PRO Electronic System Exposure Meter was the instrument used to meter the light.

The experimental design selected for this investigation was the post-test-only control group design. Statistical analyses were made using a two-factor ANOVA for each of the study's independent variables, illuminated environment, and diagnosed learning style preference. The dependent variables were the comparison of mean test scores on the reading test.

As a result of the two ANOVA's performed on the main effects of learning style preference for light and the illuminated instructional environment, the null hypothesis of there being no significant difference between the mean speed and accuracy scores of fourth-graders failed to be rejected at the .05 level. In fact, an individual's preference for either bright or subdued light did significantly affect both reading speed and accuracy when the student was tested in the preferred setting. The analyses of the interaction effects with respect to reading speed and reading accuracy scores produced significant interactions between illuminated instructional environment and learning style preference at the .01 level.

These findings indicated that students tested in illuminated instructional environments that matched their identified preferences for light achieved significantly higher reading speed and reading accuracy scores than the subjects tested in illuminated environments mismatched with their learning style preference.

London (Artificial Lighting)

Once again, different types of lights were used in the classroom to ascertain the effects of distorted spectrum fluorescent light (DSF) and full-spectrum fluorescent light (FSF) on students. London (1987) maintained the null hypothesis that there would be no difference in the effects of DSF and FSF.

In order to conduct the study, the DSF lights in three classrooms of an elementary school in Vermont were replaced by FSF lights (Vitalite) during a school holiday. These three classrooms of students between the ages of five and nine were chosen primarily because their rooms were on different sides of the building.

At the end of the school year, London tabulated from the attendance records the total number of daily absences due to illness during September, October, November, and December (seventy days), before the Vitalites were installed. The same was done for January to the end of June (105 days), after the FSF lights were in place. The study was not a blind study; however, neither the students nor the staff had any expectations that the FSF lighting might affect sickness absences.

Before the FSF lighting was introduced, the illness rate in the designated classrooms was not significantly different from that in the rest of the school or in the three classrooms that were paired with them. There was no evidence that students in the experimental rooms began the study any healthier than the other children.

When the FSF light was in place, the sickness rate in the experimental classrooms was lower than that in the rest of the school and in the three paired classrooms. When compared with the rest of the school, the significance was < .01, and in the three paired rooms the significance was < .05. This effect was a reverse of the usual seasonal pattern in the school, wherein sickness absences increased during the winter and spring months. As expected, in classrooms without FSF lighting, the rate of sick days increased significantly from January through June, compared to the time of September through December. In the FSF classrooms, the sickness rate fell slightly.

It should be noted that the DSF lighting raised the serum cortisol level more than the FSF did, and glucocorticoids suppressed cell-mediated immunity. London went so far as to suggest that perhaps FSF light, which is used to treat seasonal affective disorder, may be useful in the treatment of immune disorders.

The teachers found the FSF lighting brighter, more natural, and more pleasant. They did not wish to return to the DSF lighting.

Sydoriak (Artificial Lighting)

Sydoriak (1984), as synthesized earlier in this document, conducted her study to ascertain the effects of color and light combinations in the learning environment on students. The design included the introduction of three artificial light sources to be used with four treatment groups and two comparison groups.

During the summer break, classrooms were modified for the treatment. Scores on the Spring test of the Iowa Test of Basic Skills were recorded for each

student as the pre-test. This standardized test served as the post-test, too. Blood pressure readings were taken for all of the students from each of the treatment groups, as well as height and weight data for each student. Analysis of variance was used to determine whether the differences in two or more group means were greater than would be expected by chance alone.

Of the 112 students who began the experiment, 96 completed the study. Students in the classroom with cool-white fluorescent lighting and blue walls had lower mean systolic and diastolic blood pressure readings than students in the treatment group with cool-white fluorescent lighting and antique white walls. However, no significant difference was found between the means of the two groups on composite achievement, mathematics, or reading. It appeared that incandescent light and cool-white fluorescent light had no effect on student achievement. Full-spectrum fluorescent light did influence reduced diastolic blood pressure, but the difference was not significant.

Wohlfarth (Artificial Lighting)

This Canadian study was conducted to ascertain the effects of light and color on elementary students in a northern climate. As explained earlier in this research, the independent variables were exposure to full-spectrum light and prescribed warm or cool colors. Grade five students were exposed to ultraviolet light, and electromagnetic radiation was eliminated for a sample of grade three students.

Wohlfarth's (1986) study had the greatest findings in the area of light. There was a strong effect found between ultraviolet light and absences due to illness. Elimination of electromagnetic emissions from fluorescent lights resulted in a decrease in classroom off-task behaviors for classroom groups, but not for triad groups that had been selected for hyperactivity. These findings were of profound practical significance.

Jue (Natural Lighting)

Approximately 136 students participated in this study in which Jue (1990) hypothesized that the effects of school settings can best be understood from an interactionist perspective. He considered the joint influence of individual differences and physical design factors of facilities.

Data were collected by student interviews, behavioral observations, teacher questionnaires, and detailed surveys of the physical classroom setting. Behaviors were observed and identified that were indicative of adaptive responses to stressors in the classroom.

Although Jue was cautious about the validity of his study, he thought that the research added to the knowledge about how facilities affect children. As a main factor, the amount of window area was found not to be a significant predictor of any of the outcome measures, but there was an interaction between that variable and task inattention. Jue's research differentiated between Type A and Type B students. Type B students were more inattentive as the amount of window space increased.

Cash (Artificial and Natural Lighting)

Although Cash's (1993) study has been reviewed numerous times in this synthesis, it should be noted that most of the schools participating in the research had windowed rooms. "When the scale score means were compared between the two groups (those with windows and those without), the group in which all instructional classrooms had windows had a three point higher mean" (p. 64) on the Test of Academic Proficiency.

Lighting in the classroom was compared by incandescent or fluorescent and hot or cold. The ten schools with hot fluorescent lighting had a mean scale score of 192. The twenty-five schools with cold fluorescent lighting had the lowest mean scale score of 186. Those schools with incandescent light had a mean scale score of 189. No conclusions could be drawn.

Earthman, Cash, and Van Berkum (Artificial and Natural Lighting)

Using the same methodology as the previous study, the results for this one were different. High schools in North Dakota rated as substandard for the number of windows had a scale score mean of 802.5. Those rated as above standard had a score of 804.4.

The same trend was true for high schools with substandard and above standard lighting. The scale score means were 802.9 and 805.3 respectively.

Harting and Delon (Artificial and Natural Lighting)

This study replicated studies done in Canada, Vermont, and Florida. Four Missouri school districts and two fluorescent lamp manufacturers conducted the

study involving fifty-two classrooms, thirty-nine experimental and thirteen control. These researchers (1990) set up an equal number of experimental classrooms fitted with three different types of enhanced-spectrum fluorescent lamps. The experiment was conducted blindly in five designated schools. Neither the teachers nor the researchers knew which classrooms contained the special lamps until the study's completion.

For two months, the school administrators collected absentee data for each of the classrooms. During the semester break, maintenance crews installed the three different types of enhanced-spectrum lamps and ultraviolet light-transmitting lenses. The control classrooms remained equipped with conventional cool-white fluorescent lamps. School personnel, again, collected absentee data, along with information regarding which lamps the teachers preferred.

Chi-square tests of independence were completed to identify any relationships between student absences and types of lighting. The light meter reading produced continuous data from which means and standard deviations were calculated. Pearson product-moment correlation coefficients were generated to examine relationships between light intensity and absences.

Although, there were no controls to ensure that students attending windowless schools constituted a sample that was equivalent to those in the schools with windows, the findings indicated that the rate of student absenteeism was significantly ($p < .01$) higher in the windowless schools than in schools with

windows. In three of the four schools, there was ample evidence that classrooms having conventional cool-white fluorescent lighting, or other lighting sources not providing an ultra-violet component, had higher absence rates than in those with light sources that supplied this component.

Student absence rates seemed to be unrelated to light intensity in the classroom and did not appear to be related to grade level for students in grades one, two, and three.

Although the study seemed to reinforce the findings of similar studies, Harting and Delon suggested continued research with artificial lighting.

Hines (Artificial and Natural Lighting)

Hines (1996) simply asked the building administrator if the light in the instructional area was incandescent or fluorescent. Incandescent was considered substandard and fluorescent was considered above standard. The mean scale score for the six schools that used incandescent lighting was 199.25. The above standard school had a mean scale score of 197.43. No conclusions could be drawn.

Twelve schools rated their facilities as substandard when they considered the number of windows in the instructional areas. Their scale score means on the Test of Academic Proficiency for grade eleven was 192.94. For the twelve standard schools, their mean scale score was 194.43. The forty-one above standard schools had a score of 199.65. This indicated that there was an

improvement in test scores as the number of windows in the instructional areas increased.

Nicklas and Bailey (Artificial and Natural Lighting)

Nicklas and Bailey (1995) investigated the relationships between elementary and middle school student performance and natural daylighting in the facilities. There were three schools, designed around a daylit prototype, in the county of the

State of North Carolina where the study was conducted, and the performance in those three schools was compared to the county-wide test results. The study also included one new middle school that was not of the daylit design.

The daylit schools were constructed to maximize daylighting through the use of south-facing roof monitors that allowed controlled sunlight to enter into all major occupied spaces within the schools. The following is a description of the design:

> The roof monitors were designed to provide superior lighting (in excess of 70 foot-candles) two-thirds of the time during which the spaces were to be utilized. In all cases the roof monitors were equipped with baffles which eliminate glare into the rooms and with light sensors which control the artificial lighting. Smaller windows were also incorporated for view but were not a significant element in the daylighting strategies (Nicklas & Bailey, 1996).

Statistics from the California Achievement Tests (CAT) and End-Of-Grade Tests were used to compile the necessary summaries for student performance for pretest information for all of the county schools. This included scores from

sixteen elementary and eight middle schools. These same two instruments were used to assess performance once the daylit schools were all in operation.

When using these instruments, the researchers considered improvement in performance within each school from 1988 to 1992, 1992 to 1993, and 1994 to 1995. They reviewed the relative improvement in performance between the schools they designed and the improvement in the system-wide average for similar grade levels. First year student performance at a fourth daylit school was reviewed, and the relative improvement in the performance of another new, non-daylit middle school in the same school division was included as well.

To exclude the variables that could not be controlled from school to school, such as the student and teacher composition, Nicklas and Bailey did not make comparisons between the various schools. They drew their conclusions from the relative improvement within each school.

In one elementary school, the researchers were able to trace the progress of the students through several classroom environments. In 1988 this school burned to the ground. While the new daylit school was being constructed, the students were housed in mobile or temporary facilities.

Before the fire destroyed the elementary school, their scores on the CAT's were seven percent higher than the norm within the school division. When the students were housed in the temporary structures, their performance dropped ten percentage points the first year and four during the second. The following two years, their performance level increased to nine percent above the norm for

the county. When compared to the total county performance, the county-wide average score increased by twelve percent, while the increase at this elementary school was fifteen percent.

At the two middle schools, it was more difficult to compare the students' progress. The base scores used for improvement were the scores from the first year of the End-Of-Grade testing that was given to the students during the first two months they were in the daylit schools. The same was done at the new non-daylit middle school.

Surprisingly, the fact that the non-daylit middle school was new was not indicative of a large increase in test scores. Between 1988 and 1992, the average CAT improvement in the school division was nine percent. The new non-daylit middle school experienced a four percent decrease in test results. When the researchers looked at only the first year in the new school, the results were similar. The county-wide average improved two percent, while the new non-daylit school decreased by six percent.

Although the results were not measured by very sophisticated analyses, the daylit middle schools performed much better overall. While the county-wide increase in scores was five percent, one middle school improved by seven percent and the other by eighteen percent. When the researchers tracked the older students who had attended the daylit school for three years, there were even greater improvements.

CHAPTER 3

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

In 1982 when McGuffey presented the findings of his synthesis on facilities, he noted that:

> The alternatives for presenting the findings are limited to (1) eliminating judgmental conclusions and numerically tallying the findings of significance or (2) drawing conclusions based on the reviewer's judgment while attempting to control recognized bias. One must always keep in mind that because of the nature of research in education, it rarely, if ever, proves anything. Studies producing on similar results give added support to our confidence about other results.

McGuffey then continued by presenting the findings of his synthesis per independent variable.

Weinstein (1979), too, appeared to struggle with interpreting the data from her synthesis on the physical environment of the school. She suggested three obstacles in fairly interpreting her findings: (1) the short period of time over which most of the studies had taken place; (2) the enormous problems of control in most of the studies; and, (3) finally, her grave doubts about some of the questionnaires used in the available research. Questions were raised about the objectivity and accuracy of such instruments.

This synthesis attempted to report on the research findings and to make conclusions that weighed the difficulties of control in educational research. It is difficult in the educational setting to randomly assign teachers and students and

to have the funding to randomly change the physical settings. There are grave problems in education in trying to match teaching methods, student abilities, and physical learning climates while conducting research. Indeed, there may be moral questions as to the appropriateness of doing such and making the research public, as well as legal questions of privacy.

Thus, the conclusions drawn in this synthesis will be weighed carefully and generalizations will be made with caution.

Summary of the Findings

Student Achievement

Maintenance and Age

Some of the more conclusive studies involving student achievement as the dependent variable included Edwards' work (Berner, 1993) in the District of Columbia. As schools that were rated in poor condition were compared to those in excellent condition, Edwards' research indicated a positive correlation in achievement scores. Good infrastructure had a positive impact on student achievement. The same was true in the study of Bowers and Burkett (1989). A significant correlation existed between students at the elementary level in regard to the relationship of the physical environment and their achievement.

Cash (1993), Earthman, Cash, and Van Berkum (1995), and Hines (1996) conducted studies that provided support for a relationship between building condition and student achievement. The relationship was evidenced in that the higher the quality ratings were of the facility, the higher the student achievement

mean scale scores in most academic areas. This was true in all three studies, especially, in the areas that were cosmetic (Table 2, p. 16).

Garrett (1980) already had completed a similar study, but he included the factor of physical plant age and achievement. As the age of the facilities decreased, there was a corresponding increase in the scores of the students in most academic areas. This negative correlation was important, but not conclusive.

Classroom Structure

Based on a 1986 study by Javor, one might conclude that no significant relationship existed between student achievement and building design. High school students who were assigned to open classrooms did not accumulate higher six-week averages than students assigned to traditional closed classrooms.

Although Javor's study addressed classroom structure, it dealt with an issue that may not be as relevant as the study a year later by Krawitz (1987). This research focused on portable and temporary classrooms versus permanent facilities. Many school divisions utilize non-permanent structures to assist with student population growth and are concerned about the effect these structures have on students. Krawitz found no convincing evidence to suggest that permanent, portable, or temporary facilities have different inputs upon student achievement as measured by standardized tests. Students did not appear hindered by the temporary or portable environment in their quest to achieve.

Although the above was concluded by Javor, a year later Mwamwenda and Mwamwenda (1987) arrived at other conclusions. They discovered in their research that the performance of students who attended schools with sufficient classrooms was significantly better than that of students who went to schools with insufficient classrooms. There was no conclusive improvement in student performance in English and science, but a relationship was confirmed.

Shea (1983) took a slightly different perspective with his research. His premise was that students who had a learning style preference for formal design would learn more in that setting. The same was hypothesized for students who preferred to learn in an informal setting. These hypotheses were retained.

Another facet of classroom structure that has been investigated was placement of furniture and seats. Students sitting in the middle of a classroom scored significantly higher than those on the sides. However, the study indicated that students performed better because of their placement, not because they chose to sit in a particular place.

The ultimate project which examined classroom structure was the study by Burkhalter (1983), who compared the achievement of students who were taught in an experiential environment to the achievement of students learning in the traditional environment. The experimental groups showed significant increases on post-test scores.

Color and Light

While the hypothesis that room color affected performance was partially supported in Bross and Jackson's (1981) and Chan's (1980) studies, Sydoriak (1984) found that blue or white walls had no effect on achievement. This was true, too, when full-spectrum fluorescent lights were compared to cool-white fluorescent lights. Neither appeared to have an effect on student achievement.

Wohlfarth (1986) used light and color in his studies. There were no consistent cause-effect relationships between a ten-month effect of simulated outdoor light or prescribed colors or light/color combinations in the school environment and student achievement levels.

On the other hand, Zentall and Kruczek (1988) did find that the use of color with hyperactive children improved their performance. However, while the study addressed color in instructional materials, it did not address the color of facilities.

As did Zentall and Kruczek, Hathaway, Hargreaves, Thompson, and Novitsky (1992) carried out more conclusive studies on light, specifically, that light did have a positive effect on rates of achievement. These researchers were adamant that lighting did not exert a neutral effect on students. Their studies caused Nicklas and Bailey (1992) to conduct research on their daylit schools that showed profound positive correlations with improved achievement over the non-daylit facility. Although, there were methodology errors that may have skewed

their results, the improved achievement scores were so dramatic that the studies should be considered.

Krimsky (1981) found no differences in achievement scores of students in different light settings, unless the setting was preferred by the students. Students learning and studying in preferred settings showed significant improvement.

Density

When Pritchard (1986) compared the achievement of pre-merger schools to post-merger schools, there was no proof for the assumption that student proficiencies in reading and mathematics were enhanced under conditions created by the new, less crowded school. In fact, tenth graders from pre-merger schools achieved notably higher means on standardized tests. Therefore, it was concluded that lack of crowding did not effect a positive impact on student achievement in Pritchard's study.

However, in later research, Rivera-Batiz and Marti (1995) found in overutilized schools, the proportion of sixth graders passing a minimum standard on reading tests was between four to nine percentage points lower than that in schools that were not overcrowded. This was true, if other variables were held constant and the schools were serving a lower socioeconomic class.

Noise

In the early 1980's, there seemed to be great interest in the effects of classroom noise on children's intellectual performances. Perhaps the most

thorough examination of the effect of noise on achievement was Hyatt's study in 1982. When the schools in this study were demographically matched, student academic achievement was significantly higher in quiet schools at all levels except one. The one exception may have occurred because a sound proofing project was underway while the research was being conducted.

On the other hand, Cohen, Evans, Krantz, and Stokols (1980) conducted a similar study and found no link between noise and student achievement. They attributed their results in the area of achievement to the fact that the study had been performed in different schools, and the classrooms had different teachers.

Noise was found, also, to be a stressor in maladjusted students (Kaufman, 1984).

Climate Conditions

After statistically controlling for the effects of socioeconomic status, the standardized test scores of students in air-conditioned schools were higher than the scores of students in non-air-conditioned schools in Chan's 1980 research. However, there were only significant findings on vocabulary scores.

Three years later, Murrain (1983) conducted a thermal study that included students' learning style preferences. He found that there was a significant tendency for students to obtain higher levels of achievement when in an environment congruent with their diagnosed learning style preference for temperature.

Student Behavior

Maintenance and Age

Bowers and Burkett (1989) concluded a significant positive relationship between modern, well-maintained facilities and student attitudes. Discipline was needed less frequently, attendance records were significantly better, and health records appeared to be better. This study was conducted with the same students moving from old facilities into new ones.

Behavior of students in above standard schools was not better than student behavior in facilities that were judged in better condition in two other studies that were reviewed (Cash, 1993; Earthman, Cash, & Van Berkum, 1995). Indeed, there were more disciplinary incidents in the above standard buildings than in substandard buildings, although the margin was small. Cash attributed this to higher expectations in the more carefully maintained structures.

Although Hines' (1996) study was a replication of Cash's, but with urban high schools, his conclusions were not as clear. Suspensions, expulsions, and substance abuse did increase as the building conditions moved from substandard to standard; however, when comparing substandard to above standard, student behavior improved.

Chan (1982) measured student attitudes in new facilities versus attitudes of students in older structures. The difference in attitude scores was indicated by an *F*-value of 19.71, which was significant at the .0001 level. The results were significant across gender, race, and socioeconomic status.

Pritchard (1986), too, compared student attitudes in new versus old facilities. The results were similar to those of Chan's study: social climate factors perceived by both students and teachers were considerably more favorable in the new school. The students perceived higher expectations of learning when there was an awareness of the importance of safety and orderliness in the school, greater clarity of the school's mission, more monitoring of student progress, and greater interaction between parents and school administration.

In a study with approximately four hundred students in 1983, Karst's research had similar results. Students in poorer rated classrooms had consistently poorer user attitudes than students in "top" rated schools.

In a study conducted in Hong Kong (Cheng, 1984) with over twenty thousand students, attitudes toward the facility were found to affect student attitudes toward homework and intentions to drop out. Effective classrooms were perceived as being equipped with appropriate physical facilities, having enough space, and being neat, clean, and free of pollution.

Classroom Structure

When students who were very young were permitted to express their preferences for classrooms, they had the capacity to discriminate among various environmental settings. Cohen and Trostle (1990) found that very young children preferred educational settings that provided opportunities for movement,

investigation, concentration, and social interaction. Regardless of age or gender, students had color, texture, and lighting preferences.

Student satisfaction with the facility was measured by Ahrentzen and Evans in a 1984 study to discover whether particular classroom environmental features influenced distraction, privacy, and general student satisfaction. They found that few architectural features affected student distraction. Open perimeter space was also unrelated to distraction, but was associated with less classroom satisfaction, as greater structural walls were positively related to student satisfaction. The researchers did not think that their results on privacy were valid because of the limited definition of privacy that was used. This was exhibited in the results that secluded study space, as single desks were consistently associated with less perceived privacy. This part of the study met difficulty, too, because teachers did not permit students to be out of the line of vision.

In 1984, Cotterell found that students in open plan schools scored significantly higher on school work anxiety. A year later Heubach (1985) confirmed in his study that a complex relationship existed between student privacy requirements and the structure of the classroom or the school. Students needed areas in which they could be monitored, yet have a feeling of privacy.

Hood-Smith and Leffingwell (1983) carried the privacy concept a step further by stating that students have reduced anxiety when there was a planned, ordered environment that allowed for control. Tension, anxiety, and stress were

reduced as a result of alteration to the physical space. Jue (1990) concurred with these findings, but he made exceptions based on different types of students. For instance, openness of the classroom perimeter explained a significant proportion of the variance in absenteeism, task inattention, and fidgeting in Type B students. The presence of discrete areas where students could go and work away from the rest of the class was associated with high levels of inattentiveness in extreme Type A students.

In a recent study by Peatross and Peponis (1995), it was discovered that students created privacy or "buffer" zones when none existed. These researchers believed that their study showed that space not only affected the educational system but also affected the spatial patterns of socialization in such a way that pedagogical codes could be shifted.

Nash (1981) attempted to connect learning outcomes to the design of the classroom. This researcher found that removing impediments to learning may be as important as designing for learning to take place. The total study was conducted by observations of different classrooms. The results were all subjective.

Neill and Denham (1982) conducted a similar study, except their research was narrowed to the influence of large and small spaces. Aggressive behavior was significantly correlated to building openness, and children spent less time on educational activities in such schools. Students spent more time watching, meandering around, and doing nothing in the open-space classrooms. On the

other hand, in the more closed areas, the observations indicated that staff-child interaction was more likely to be initiated by the staff for instructional purposes, and the children were more likely to seek out the staff.

In Stueck's (1991) study, the learning environments which encouraged confidentiality and fostered a social climate of joy, also generated self-directed learning. Overall, however, this study provided very nebulous assumptions of students' perceptions.

Stires (1980) was able to show significant effects on attitudes of students about learning by where the student was sitting. For instance, students in the back of the room were absent more often than students in the front. Where the students sat in the study had a significant influence on their attitudes toward the course.

The "soft" classroom was observed in the study by Sommer and Olsen (1980). They hypothesized that softer classrooms would increase student participation. This hypothesis was retained on the short term, but was rejected after a period of time.

Color and Light

In the lighting study of fifty-two classrooms by Harting and Delon (1990), student absenteeism was significantly higher in the windowless schools than in schools with windows. However, when the methodology was considered, it was found that there were no controls available to ensure that students attending the

windowless facilities constituted a sample that was equivalent to those in schools with windows. Light intensity did not affect the absence rate.

An intense study into the effects of light on elementary school students produced conclusions in several areas (Hathaway, Hargreaves, Thompson, & Novitsky, 1992). The color of visible light in the classrooms and lighting that contained trace amounts of UV affected the growth and development rates of children. In general, lighting had significant effects on people in the classroom to include effects on the attendance rates, health and general development, age at the onset of menarche, height gains, weight gains, and gains in body fat.

London (1987) had already conducted a similar study comparing the effects of distorted spectrum fluorescent light (DSF) and full-spectrum fluorescent light (FSF). When the FSF light was in place, the sickness rate in the experimental classrooms was significantly lower than that in the rest of the school.

Earlier Ingraham (1983) had shown that there was a reduction of total student off-task behaviors per minute when electromagnetic radiation from full spectrum lighting was reduced. The proper baseline data had been collected prior to the study, so the results can be attributed to the electromagnetic radiation.

A year later, Sydoriak (1984) added color to the problem of the study. Students in the classroom with cool-white fluorescent lighting and blue walls had lower mean systolic and diastolic blood pressure readings than students in the

treatment group with the same lighting and antique white walls. The longer the students were exposed to the blue color, the greater the effect on reducing the diastolic blood pressure.

In a 1986 Canadian study (Wohlfarth), there were no consistent cause-effect relationships between a ten-month effect of simulated outdoor light or prescribed colors or light/color combinations in the school environment and student ability or achievement levels, attitudes towards school subjects, misbehaviors warranting disciplinary action, absences due to illness, refractive eye problems, or blood pressure. However, important differences were observed between control and experimental schools in reference to treatment effects on pre-adolescent mood levels. Students in the color/light and light only schools exhibited greater feelings of urgency and mastery/self-esteem. Elimination of electromagnetic emissions from fluorescent lights resulted in a decrease in classroom off-task behaviors for classroom groups. There were some data to suggest that the students exposed to supplemental ultraviolet light experienced fewer absences due to illness than the control classes.

Recently, Grangaard (1995) conducted a brief study to determine the physiological and behavioral effects of color and light. He was attempting to replicate the research by Wohlfarth. When students were in an environment in which the walls were painted a light blue, the visual noise was permitted to be on the walls, and the lights were changed to FSF, the group mean systolic blood pressures of the students decreased dramatically. Off-task behaviors

decreased, as well. Blood pressures and behaviors gradually reversed when the bulletin boards of red and orange, white semi-gloss walls, and cool-white fluorescent fixtures were returned to the students' environment.

Density

While Cheng (1994) concluded that students rated effective classrooms as being equipped with appropriate physical facilities and having enough space, Rivera-Batiz and Marti (1995) conducted a much more in-depth study that indicated overcrowding had a clearly defined negative impact on concentration and finding places to study quietly. Nearly half of the non-graduating students surveyed did not want to remain in the overcrowded schools.

Burgess and Fordyce in their 1989 study found indications that for younger students, the density of classrooms may have a greater negative impact than hypothesized. The results suggested that nursery age students may find the typical classroom to be confining. Primary students need space for free-play, which normal size classrooms do not provide. As the students become older, Peatross and Peponis (1995) found that students changed the spaces around them to provide visual barriers and privacy.

Jue (1990) did not differentiate by age but by psychological personality types. In this study, density was a significant predictor of task inattention, but there were marked differences in the frequency of off-task behaviors between Type A and Type B students. Type B students were much less affected by density.

Noise

The results of the study by Cohen, Evans, Krantz, and Stokols (1980) were consistent with previous laboratory work. Children from noisy schools had higher blood pressures and were more likely to quit on a task than children from quiet schools. In addition, increased years of exposure to aircraft noise led students to being more distractible rather than less, indicating a lack of adaptation. Although noise-school students were shorter and weighed less than quiet-school children, the differences were not conclusive.

Two years later, Hyatt (1982) conducted a similar study in which students in noisy schools perceived their classrooms to be noisier, more confusing, and the noise to be an interference. There were significant findings in student attitudes about ability to hear lectures, assignments, and discussions, and feelings that the noisy classrooms were uncomfortable, unsettled, and unpleasant.

Using a different approach, Pizzo (1981) tested students to ascertain their learning style preference for quiet or noise. The results supported the conclusion that students tested in acoustic environments congruent with their preferences for sound achieved higher attitude scores than their peers tested in incongruent environments.

Noise definitely had an adverse effect on hyperactive children (Zentall & Shaw, 1980). Hyperactive students were more active in high noise situations and completed fewer problems correctly than did the control students.

Finally, Kaufman (1984) found that non-related, ambient classroom noise caused great stress in the students studied. This was especially true with children identified as potentially at-risk or maladjusted.

Climate Conditions

Scagliotta (1980) discovered that a definitive relationship existed in his study between decreasing atmospheric pressure and maladaptive behavior in children. This research was not intended to implicate this as the only condition affecting negative behavior, but this may be used as an indicator.

A few years later, Kaufman (1984) collected data through naturalistic research methodology that identified temperature as a stressor. Excessively hot external temperature and humidity in the classroom not only caused stress, but was related also to a child's ability to learn and retain information. In addition, there appeared to be a relationship between temperature and the emotional climate in the total classroom.

Conclusions from the Findings

The conclusions that are drawn from the research are important not only for the information that they provide the educator and the building designer, but also for how they substantiate or disagree with the two previous syntheses by McGuffey (1982) and Weinstein (1979). Therefore, conclusions from the three syntheses will be included in this discussion.

1. School facilities that are well-maintained have a positive impact on student achievement (Bowers & Burkett, 1989; Cash 1993; Earthman, Cash, &

Van Berkum, 1995; Edwards, 1993; Garrett, 1980; Hines, 1996). This statement was supported in the work of McGuffey (1982), who concluded that obsolete learning environments detract from the learning process. On the other hand, Weinstein (1979) was unable to state conclusive statistical data that the physical environment had impact on achievement. Her study did concede that the physical environment affected attitudes, and positive attitudes may result in improved achievement.

2. School facilities that are maintained well positively influence student behavior (Bowers & Burkett, 1989; Chan, 1982; Cheng, 1994; Karst, 1983; Pritchard, 1986; Hines, 1996). This was supported in McGuffey's study, and was not disputed in the work of Weinstein.

3. Students will seek areas of privacy in the classroom, even if they must create the structure themselves, as classrooms with areas for privacy reduce student anxiety and stress. (Cotterell, 1984; Heubach, 1985; Hood-Smith & Leffingwell, 1983; Jue, 1990; Peatross & Peponis, 1995). Although this was not a variable addressed by McGuffey, Weinstein saw privacy as a variable that needed additional study. Perhaps Weinstein's recommendation was the reason that this synthesis had five studies to review.

4. Full-spectrum fluorescent lighting with trace amounts of ultraviolet content has a positive effect on student health (Grangaard, 1995; Hathaway, Hargreaves, Thompson, & Novitsky, 1992; London, 1987; Wohlfarth, 1986). Although neither McGuffey nor Weinstein addressed this variable as the current

synthesis did, McGuffey concluded that seeing factors had a significant effect on visual performance. However, he stated that natural light had little or no effect on classroom performance.

5. Non-instruction noise has an adverse effect on the student learner (Cohen, Evans, Krantz, & Stokols, 1980; Hyatt, 1982; Kaufman, 1984; Pizzo, 1981; Zentall & Shaw, 1980). McGuffey found that noise could create enough interference with instruction that learning would be hindered. Weinstein could find no conclusive evidence that noise affected achievement, but did state that classroom noise levels should be realistic.

All three syntheses indicated the importance of the physical environment to the student.

Recommendations

Recommendations from the Researchers

As the studies in this synthesis were reviewed, the researchers made recommendations for further study, recommendations to educators and designers, and suggestions to other researchers on how the research should be conducted. The following provides a list of some of those recommendations.

1. Researchers often assume that they have identified all of the independent variables in a study. With such a complex variable as student achievement, Edwards (1991) suggested that it was unwise to assume that any model included all relevant independent variables and to consider any conclusions accordingly.

2. Cash (1993) and Talton (1983) recommended further study concerning the relationship between student attitudes and building condition in order to discover the origin of dependence. If student attitudes, evidenced by pride in surroundings, less graffiti, and overall concern for the facility, are responsible for building condition, then attitudes should be addressed. If building condition is responsible for attitudes, building condition needs to be improved.

3. Educators and architects should spend more time in schools observing and talking with students. This would enable them to design buildings that are more student-centered (Karst, 1983; Coffey, 1992). This is an important recommendation if the link between satisfaction with one's environment and behavior and attitudes is considered.

4. Many of the researchers recommended replications of their studies to provide a wider basis for findings or conclusions and to increase substantially the impact of their research (Cohen, Evans, Krantz, & Stokols, 1980; Cohen & Trostle, 1990; Fletcher, 1983; Harting & Delon, 1990; Hathaway, Hargreaves, Thompson, & Novitsky, 1992; Heubach, 1985; Hines, 1996; Ingraham, 1983; Knight, 1990; Krimsky, 1981). For those studies that have followed a defensible methodology and protocol, such replication is necessary in order to build a more convincing data base. It is also necessary to permit an expansion of the populations studied. Several studies in this synthesis contained very valid research, but with an extremely limited population base.

5. Professors in schools of education should consider course content that includes materials dealing with the classroom physical environment and its possible effect on the learner (Greabell & Forseth, 1981).

6. Additional research needs to be conducted to ascertain the link, if any, between teacher attitudes and the facility. In turn, the influence of teacher attitudes on the attitudes of students should be investigated (Hyatt, 1982; Shea, 1983; Yielding, 1994).

7. A format of protocol needs to be developed for future studies in order for the data to be comparable for a future meta-analysis (Earthman, 1996, October).

Recommendations for Further Study

The purpose of this study was to review and synthesize systematically the research findings from the various studies pertaining to school facilities, student achievement, and student behavior. While conducting this review, there were gaps in the research or suggestions for protocol and methodology that need to be addressed.

1. Many of the studies in this synthesis were of short duration. Substance would be added to results and conclusions, if the researchers followed student achievement and behavior with longitudinal research.

2. Researchers were often negligent in care taken with methodology issues. For example, research of this kind requires the use of nonprobability sampling and depends on volunteers responding to questionnaires. Controlling all of the variables in the classroom is nearly impossible. These factors need to be considered when stating findings, and methodology should be incorporated to lessen the influence of all but the designated variables.

3. Some of the results of the research were questionable because of flawed methodology. Therefore, studies with improved and concise methodology should be replicated. These include, but are not limited to, those studies by Earthman, Cash, Chan, Hines, Edwards, and Garrett. In addition to replication, there should be efforts to conduct the studies in various climates, in different geographical areas, and at different grade levels.

4. Another area of needed research deals with the

> "possible relationship between the leadership and financial ability found in the school system and the condition of the schools. Does the leadership provided by the administration and school boards determine the condition in which the schools are which in turn influences the attitudes of students?" (Earthman & Lemasters, 1996, p. 11).

As in the model developed by Cash (Figure 1, p. 208), leadership and financial ability provide the base that ultimately affects the building condition. Most of the research in this synthesis studied the direct results of the facility on student attitudes and achievement. More inquiries should be made into whether or not the leadership's and community's financial support of school buildings sends value statements to the students that influence their attitudes toward learning.

Conclusion

There are many variables that influence student achievement, student attitudes, student behavior, and how students learn (Table 3, p. 204). The problem for all of the studies in this synthesis was determining the degree to which the school facility actually was the cause of student behavior and achievement. (An explanation of the symbols are on the page following the chart.)

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Table 3
MATRIX OF DEPENDENT AND INDEPENDENT VARIABLES BY STUDY

STUDIES	DEPENDENT VARIABLES		INDEPENDENT VARIABLES							
	Achievement	Behavior	Noise	Age	Color	Lighting	Maintenance	Density	Climate Conditions	Classroom Structure
Ahrentzen		•	S					S		N
Edwards	•			R			R			
Bowers	•	•		S						
Bross		•			N					
Burgess		•						R		R
Burkhalter		•								S
Cash	•	•	NR	R	R	R	R	NR	R	
Chan (80)	•				N	N			S	
Chan (82)		•		S						
Cheng		•					R	R		
Christie	•		R							
Cohen (80)		•	R							
Cohen (90)		•			R	R				R
Cotterell		•								R
Earthman	•	•	NR	NR	R	R	R	R	R	
Garrett	•			S						
Grangaard		•			R	R				
Harting		•				S				
Hathaway	•	•				R				
Heubach		•								R
Hines	•	•	NR	R	NR	R	R	NR	R	
Hood-Smith		•								R
Hyatt	•	•	S							
Ingraham		•				NR				
Javor	•									N
Jue		•				N		S		N
Karst							R			
Kaufman		•	R						R	R
Knight	•		N			N			N	
Krawitz	•									N
Krimsky	•					N				
London		•				S				
Murrain	•								N	
Mwamwenda	•									R
Nash		•								R
Navarro	•									N
Neill		•								R
Nicklas	•					R				
Peatross		•						NR		R
Pizzo	•		R							
Pritchard	•	•		R						
Rivera-Batiz	•	•						R		
Scagliotta		•							R	
Shaw	•									S

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Note. * indicates there were two studies represented in these cells. S indicates significant findings (at least .05 level of significance). N indicates no significant findings. R indicates there was a relationship found. NR indicates there was no relationship.

From the research synthesized in this study and all other studies, educators and design professionals should consider the impact of building condition, lighting, or site noise when planning, remodeling, and designing schools for the twenty-first century. To support the above statement, Table 4 provides the number of studies that had significant findings or found a relationship of achievement

Table 4

STUDY FINDINGS OF EFFECTS OF INDEPENDENT VARIABLES

Independent Var.	Significant Find.	Non-Significant	Relationship	No Relationship
Noise	2	1	6	3
Age	3	0	4	1
Color	1	2	8	1
Lighting	2	5	8	1
Maintenance	0	0	7	0
Density	2	0	4	3
Climate Conditions	1	2	5	0
Classroom Structure	3	5	12	1

Note. This table totals the number and type of findings for each independent variable.

or behavior to the school facility. Although not conclusive, there was evidence that all of the independent variables in Table 4 affect the dependent variables of student achievement and behavior.

Even when the variance of achievement test scores resulting from the building environment is minimal, it is a portion of the elements affecting behavior and achievement that can be controlled through the efforts of educators and design professionals. In addition, the condition of school buildings is a very visible demonstration or value statement made to the student of the importance that society or the community places on education.

As stated by Edwards (1991) in her study:

> Good infrastructure is truly at the base of a quality education. For a society searching for ways to address the educational needs of the future, the building itself is a good place to start (p. 47).

After reviewing over fifty-three studies and reading the U. S. General Accounting Offices' facilities report (1995), one could hardly disagree with Edwards.

The last section will address the implications for practice and the problems facing the researcher and the local communities as they address the needs of the school facility.

Discussion

A 1995 report by the General Accounting Office (GAO) suggested fourteen million students attend schools needing extensive repair or replacement. According to Senator Moseley-Braun (press release, June 21, 1996),

> Crumbling schools is not just an inner city problem. It is not a problem for poor children, or for minority children. . . .It is an American problem--and it relates directly to our future. . . . America can't compete if our students can't learn; and our students can't learn if their schools are falling down.

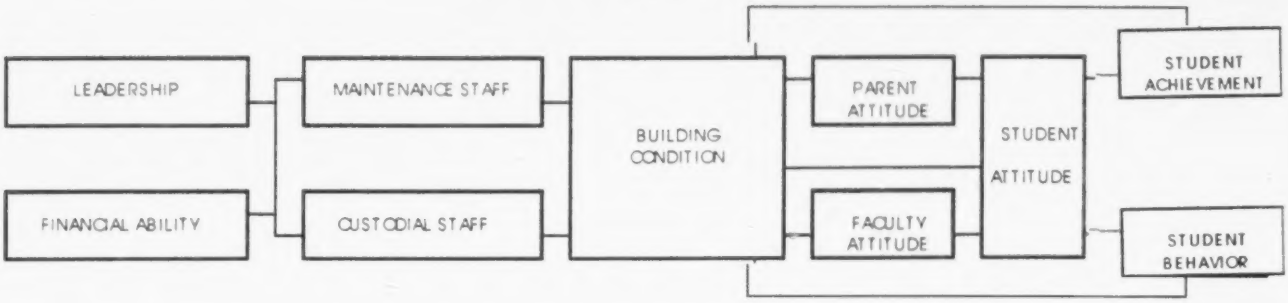
From state and federal documents presented in the GAO study and from the available research on how the facility affects student achievement and behavior, it is illogical that resources are not available to address maintenance, renovation, and construction needs. In the State of Virginia, for example, the allocation for maintenance of facilities is very small. The funding is static, as the legislature often lowers the allocation when the budget is tight. As for the construction of new facilities, the Commonwealth provides only funds for loans. There are many problems contributing to this lack of action. There is also the question of why the research is not used and why educators do not translate data from the research into design and increased funding for remodeling, maintenance, and construction.

Implications for Practice

In the discussion of the implications for practice that need to be considered by educators and researchers, the model developed by Cash will be referenced (Figure 1).

Figure 1

CASH'S THEORETICAL MODEL



The first element that directly or indirectly affects the building condition is leadership. This may be the leadership of the locality, the leadership of the school division, or leadership at the building level. A breakdown at any one of these levels, a lack of acknowledgment of the importance of the facility, will eventually affect the physical structure and ultimately the student.

There is a direct connection, too, in how the funding flows for maintenance, remodeling, and construction. Funding is directly related to the convictions of the leading powers in the state and localities as to the importance of the facility. Often funds are cut for schools as politicians and educators fail to recognize the impact of the facility on the student or the educational process. It

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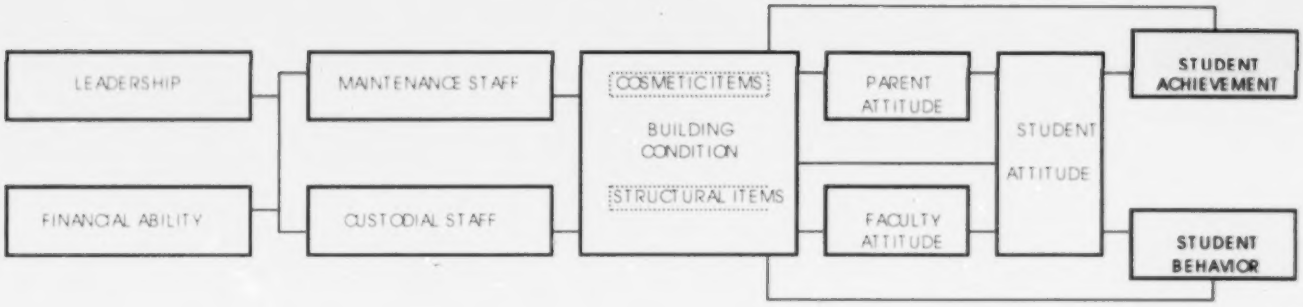
would be negligent not to mention that the ability to pay may hamper the role of leadership to provide the necessary funding.

In the theoretical model another factor, the maintenance and custodial staffs, directly relates to the condition of the building. There are two important components that affect the tasks that these employees perform. First, their work is only as good as the funding which they are provided to accomplish their tasks. Secondly, no matter the level of funding, there must be an explicit mission shared with these staffs that maintenance, custodial tasks, and grounds work are an important part of the total education process. There must be a shared vision that clean buildings, facilities in good repair, and schools that provide an infrastructure necessary for the twenty-first century curricula are necessary.

According to the implications in the theoretical model, building conditions are influenced by leadership, funding, and staffs. However, the concept of building conditions should be expanded to include structural and cosmetic conditions as noted in the research of Cash and Hines. Designers and educators need to realize that there are many components that compile the building condition (Table 2, p. 16). Therefore, the theoretical model should be modified to include the reminder of the elements comprising the total concept of building condition (Figure 2, p. 211).

Figure 2
REVISED THEORETICAL MODEL



The building condition in turn affects the attitudes of three groups of clients: parents, faculty, and students. This is a complicated relationship, as the building has a direct influence on the student as well as an indirect relationship on the student via the parents and faculty. The relationship is one that lends itself to compounding and exacerbation, if the facilities are in poor condition. Ultimately, there is a message to all of the stakeholders that education is of lesser importance when the community fails to fund the appropriate environment for learning.

The final effects of the building condition are related directly to student achievement and behavior. The literature supported throughout this synthesis that the resultant attitudes and behaviors of students improved when the facility improved or was congruous with the facility needs for the instructional program. Even when studies indicated increased suspensions or disciplinary actions in improved buildings, there were suggestions that this was related to higher expectations for students.

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Using the revised theoretical model as a guide, school boards and educators need to address the following in conjunction with the facility:

1. Leadership,
2. Funding, and
3. Staffing.

Researchers must develop a common or similar methodology and protocol that adds support to the already available data. Finally, designers should incorporate the available research into their designs. In order to accomplish these tasks, there are problems to be addressed.

Problems

This researcher has already recommended that the studies of Earthman, Cash, Hines, Chan, Edwards, and Garrett be replicated. In addition, suggestions were made to conduct the studies in various climates, geographical areas, and at various grade levels. However, there are more specific problems to be solved.

One of the first problems can be observed in the matrix (Table 3, p. 204) developed from the studies reviewed in the synthesis. The matrix lists the studies by author, with bullets indicating the dependent variables and letters indicating the independent variables. While the codes used in each cell of the matrix should be meaningful to the designer and educator to discover what each researcher says concerning a particular variable, the cells that are empty are important to future researchers. The empty cells indicate areas in which there are few studies or where research may need to be conducted. While Earthman noted two hundred thirty-two studies in the syntheses by Weinstein, McGuffey, and others and while this synthesis adds fifty-three studies to that total, there continues to be a need for further research. The empty cells may assist in targeting the variables for those studies.

In addition to providing suggestions for areas of future study, it should be noted that further research would allow for expansion of the population base. The ultimate span for study would include a stratified, selected sample from the school building population across the North American continent. As this would

be a very huge and expensive operation, selected samples from various regions of the continent would be more workable.

However, this research needs to be similar enough in intent, methodology, protocol, and variables to later add to empirical data. One such obstacle that needs to be addressed will be the type of achievement examinations the locality, state, or province uses. Multiple states and provinces have volunteered to provide the populations to be the participants in future studies; however, they do not administer any common achievement examination. Thus, researchers must find statistically accepted methods of measuring achievement.

A second area that needs to be addressed in any new studies is assurance of representation from multiple geographic areas; from large and small school divisions; from rural, suburban, and city school systems; from divisions with various economic bases; and, from different levels of the school population. Sample populations within each of these identities must be participants in the studies.

Third, each study must use common instruments to determine the physical condition of facilities. Not only should the same documents be used to appraise the conditions of the learning environment, these surveys should be completed by the same level of building administrators or personnel. For example, data cannot be compared that has been supplied by principals in one study and teachers in another.

Fourth, the data must be analyzed using similar statistical procedures. In addition the achievement scores and the behavior ratings should be adjusted for socioeconomic status.

In summary, the purpose of this study was to synthesize the research findings since 1980 pertaining to the condition of the school facility and how it affects student achievement and behavior. A matrix was developed to identify the researchers and the variables included in their studies. Finally, a theoretical model was discussed that was developed by Cash and substantiated in the research of Earthman, Hines, and this synthesis. This evidences a body of data that can be used by educational leaders and politicians to support the place where students learn. The body of knowledge also can be used by designers to build facilities with research based designs. Appendix D provides an important, although incomplete, list of suggestions from the studies that may be useful to the professionals who plan, build, maintain, and remodel school facilities.

With all of the many elements within the educational process that are outside of the control of the educator, it is possible to provide a school building that exemplifies to the student the importance that the community, the state, or the nation places on education. The place where students learn can encourage good student behaviors and optimal student achievement.

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APPENDIX A

DESCRIPTORS FOR SEARCHES

acoustics
acoustics and student achievement and behavior
behavior
behavioral sciences in buildings
classroom and color and student achievement
classroom and color and student behavior
classroom color
classroom color and student behavior
classroom design
classroom design and student achievement
classroom design and student behavior
classroom environment
classroom environment and behavior
classroom environment and student achievement
color
color and student achievement and behavior
color and student behavior
crowding
crowding and student achievement
crowding and student behavior
educational environment
educational environment and achievement
educational environment and behavior
educational facilities
educational facilities and achievement
educational facilities and behavior
environment and behavior
environment and schools

environmental factors and student achievement
evaluation of facilities and student achievement
facilities and student behavior and achievement
facilities and students
facilities and students and behavior
facilities and students and achievement
facilities planning
facilities planning and student achievement
facility design and student achievement
facility design and student behavior
light
light and acoustics and density and color
light and color
light and schools
light and student achievement and behavior
maintenance and student achievement
maintenance and student achievement and behavior
maintenance and student behavior
new construction and student achievement
new facilities and old
new school and student achievement
new school and student behavior
new schools
new schools and old
noise
old schools
physical environment and student achievement
physical environment and student behavior
research and behavior
research and schools
school and building and age and achievement
school and building and age and behavior
school building age
school building age and student achievement
school building and student achievement

school building maintenance
school buildings and achievement
school buildings and behavior
school design
school design and achievement
school design and behavior
school space and achievement
school space and attitudes
school space and behavior
schools
schools and behavior
schools and light
student behavior and achievement
temperature
temperature and student behavior
thermal and student achievement
windows and student achievement

APPENDIX B

REVIEW OF RESEARCH

Name of Researcher(s): _____

_____

Title of Document: _____

_____

Statement of the Problem: _____

_____

_____

Hypothesis(es): _____

_____

Methodology: _____

_____

_____

_____

_____

_____

_____

_____

Population in the Study: _____

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_____

Variables Addressed in the Study:

Student Achievement _____

Student Behavior _____

Building Condition _____
Age _____
Maintenance _____

Classroom Structure _____

Climate Conditions _____

Color _____

Density _____

Lighting _____

Natural _____

Artificial _____

Noise _____

Findings: _____

APPENDIX C

MEASUREMENT OF DEPENDENT VARIABLES

RESE-ARCHER	ACHIEVEMENT	BEHAVIOR
Ahrentzen	-	Student satisfaction with classroom
Edwards	Comprehensive Test of Basic Skills	-
Bowers	Scores in reading, listening, language, and math	Attendance; discipline incidents; Piers-Harris Self-Concept Scale
Bross	-	Errors on a mirror tracing
Burgess	-	Free-play behaviors
Burkhalter	-	Career Maturity Inventory Attitude Scale
Cash	Test of Academic Proficiency	Number of disciplinary incidents
Chan (80)	Iowa Test of Basic Skills	-
Chan (82)	-	Our School Building Attitude Inventory
Cheng	-	Researcher developed instrument to measure attitudes
Christie	Standard Progressive Matrix (60 subtests)	-
Cohen (80)	-	Blood pressure; attention strategies; feelings of helplessne
Cohen (90)	-	Preference paradigm was developed by student
Cotterell	-	Student behavior; anxiety; peer interaction
Earthman	Comprehensive Test of Basic Skills	Number of disciplinary incidents
Garrett	Test of Academic Progress	-
Grangaard	-	Blood pressure; off-task behavior
Harting	-	Attendance
Hathaway	Canadian Test of Basic Skills	Attendance; vision changes; growth and development rate
Heubach	-	Questionnaire evaluating privacy perceptions
Hines	Test of Academic Proficiency	Number of disciplinary incidents
Hood-Smith	-	Disciplinary incidents; social behavior
Hyatt	California Test of Basic Skills; California Achievement Tests	Opinion questionnaire developed by Port of Seattle to measure attitudes
Ingraham	-	Measured inattention, off-task or disruptive behavior
Javor	Biology class averages and test scores	-
Jue	-	Task inattention; attendance; restlessness
Karst	-	Attitude inventories
Kaufman	-	Stress
Knight	Grades and tests in reading, math, language	-
Krawitz	Iowa Test of Basic Skills	-
Krimsky	Gates-MacGinitie Reading Tests	-
London	-	Attendance
Murrain	Word recognition scores	-
Mwamwenda	National exams in math, English, science, social science, Setswana	-
Nash	-	Measured student choices of activities
Navarro	Peabody Individual Achievement Test	-
Neill	-	Span of attention; disruptive behavior; aggressive behavio
Nicklas	California Achievement Tests and End-of-Grade testing	-
Peatross	-	Student circulation and interaction
Pizzo	Gates-MacGinitie Reading Tests	-
Pritchard	California Test of Basic Skills	Measured attitudes of students in new school
Rivera-Batiz	NY City Bd. of Ed. school profile data	Opinions and perceptions were measured
Scagliotta	-	Negative behavior
Shea	Metropolitan Achiev. Test (reading subtest)	00 -
Sommer	-	Student participation
Stires	Course grades	Attitudes toward the course; attendance
Stueck	-	Social interaction; student self-motivation

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APPENDIX D

NOTES FOR EDUCATORS AND ARCHITECTS

Ahrentzen	√Students wishing to be alone seek areas of privacy
	√Outside noise causes students to be dissatisfied with their classrooms
Edwards	√School age was found to be a predictor of building condition
	√Parental involvement is positively related to the school building's condition
	√As the condition of the facility improved, achievement scores improved
Bowers	√Students had higher achievement scores in newer facilities
	√There were fewer discipline incidents in newer facilities
	√Attendance records were better in the new facilities
Burgess	√Pre-school students may need more spacious classrooms
Burkhalter	√Stimulating environments promote positive attitudes
Cash	√Higher student achievement was associated with schools with air conditioning, better science laboratories, pastel painted walls, less external noise, and well-maintained schools
Chan	√There was a consistent pattern of higher achievement in air-conditioned schools
Cheng	√Effective classrooms were perceived as being equipped with appropriate physical facilities, having enough space, and being neat, clean, and free of pollution
Cotterell	√Open-plan classrooms had higher levels of off-task behavior
	√Students experienced more anxiety in the open-plan classrooms
Earthman	√Student achievement scores were higher when the following building conditions were rated above standard: windows, floors, heat, roofs, locker conditions, ceilings, laboratory age, lighting, interior paint, mopped floors, cosmetic opinions, density

Garrett	√As the age of the facilities decreased, there was a corresponding increase in scores in mathematics, reading, and composition
Grangaard	√There seemed to be a cause-effect relationship between the variables of color and light and the students' blood pressures
Harting	√The rate of student absenteeism was significantly higher in the windowless school
	√Under some conditions, classrooms having fluorescent lighting without an ultra-violet component have higher absence rates
Hathaway	√Light had an effect on attendance rates
	√Light had an effect on achievement
	√Light with ultra-violet content appeared to improve student health
Heubach	√Students are not comfortable being in low privacy areas
Hines	√Higher achievement scores were associated with newer buildings, more windows, air conditioning, good maintenance, and individually heated instructional areas
Hyatt	√Student attitudes toward the classroom environment will affect achievement
	√Noise outside of the classroom negatively affects classroom achievement
Ingraham	√There was a possible cause-effect relationship between electromagnetic radiation and students' off-task behaviors
Jue	√Density is a significant predictor of task inattention
	√Openness of the classroom perimeter explained a significant proportion of the variance in absenteeism, task inattention, and fidgeting
Kaufman	√Excessive temperatures and noise may cause stress in students
London	√FSF lighting improved attendance
Murrain	√Achievement is greater in facilities that allow for individual preferences for heat
Neill	√Children spend their time in less educationally valuable ways in more open classroom units

Nicklas	√Daylight in the classroom fosters higher achievement
Peatross	√Students will create their own privacy areas
Pritchard	√Social climate factors perceived by students were considerably more favorable in a new school
Rivera-Batiz	√Overcrowding has a negative impact on student achievement in poorer school districts
Sydoriak	√Relaxing shades of blue significantly reduce systolic diastolic blood pressure
Talton	√Attitudes toward the science classroom predict science achievement
Wohlfarth	√Classroom with full-spectrum lighting with ultra violet content has a significant effect on attendance

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Education

Ed.D 1997 Virginia Polytechnic Institute and State University, Blacksburg, Virginia; major, Educational Administration.

1996 Certificate of Advanced Studies; Virginia Polytechnic Institute and State University; major, Educational Administration.

1995 Licensed as a Division Superintendent for the Commonwealth of Virginia.

Ed.S 1991 The George Washington University; major, Supervision and Administration.

1991 Registered School Personnel Administrator by the Association of School Personnel Administrators.

M.S.A. 1978 The George Washington University; major, Business Administration (Industrial Personnel Management).

B.A. 1965 West Liberty State College; majors, Business Education and Speech.

Professional Experience

Gloucester County Public Schools, Gloucester, Virginia; 1993-Present; Assistant Superintendent for Administrative Services.

Gloucester County Public Schools, Gloucester, Virginia; 1987-1993; Director of Personnel.

Gloucester County Public School, Gloucester, Virginia; 1985-1987; Supervisor of Vocational/Computer Education.

Gloucester High School, Gloucester, Virginia; 1975-1985; Teacher.

Ft. Monroe, Virginia; January-February, 1974; Civilian Personnel; Instructor (part-time).

Thomas Nelson Community College, Hampton, Virginia; 1973-1974; Business Instructor (adjunct faculty).

Kanawha County Schools, Charleston, West Virginia; 1966-1969; Teacher.

Burgettstown Area Schools, Burgettstown, Pennsylvania; Summer, 1966; Teacher.

Hancock County Schools, New Cumberland, West Virginia; 1965-1966; Teacher.

Educational Activities And
Accomplishments

Summer, 1980: Participant, Interdisciplinary Program in Consumers' Education in Urban, Rural and Suburban Settings, Virginia Polytechnic Institute and State University.

Spring, 1983: Reviewer, Speech Area of the National Teacher's Examination.

June, 1985: Wrote and was awarded first grant for alternative education in Gloucester County.

1989-1990: Consulting projects to develop uniform pay plans, coordinated with the appropriate job descriptions.

Presenter at the local, state, and national level, including the Governor's Conference on Education (1990), the American Vocational Association national conference (1987), and the Virginia Association of School Personnel Administrators' annual conferences (1992 and 1993).

1986 and 1987: Chairperson and Secretary, Region III Vocational Administrators.

1987 and 1988: Chairperson and Vice-Chairperson, Computer Consortium for Interactive Instruction.

1994: National Convention Committee member and Sub-committee Chairperson, American Association of School Personnel Administrators.

March, 1995: Participant, invitational conference at Exeter College, Oxford University, on Educational Leadership and Ethics; sworn in as a reader at the Bodleian.

July, 1996-August, 1997: Planning director and board liaison for a 7.8 million dollar elementary school.

October, 1996: Presenter at the annual meeting of the Council of Educational Facility Planners, International.

Publications

Lemasters, L. K. (1993, March); The Negative Employee; VASPA View, 4-5.

Earthman, G. I. & Lemasters, L. K. (1997, February); The Impact of School Buildings on Student Achievement and Behavior, A Review of Research; PEB Exchange, The Journal of the OECD Programme on Educational Building, 30, 11-15.

Professional Organizations

Virginia Association of School Personnel Administrators
American Association of School Personnel Administrators
Delta Kappa Gamma Society International (Inactive)
Rotary International (Gloucester Point)
Association for Supervision and Curriculum Development
American Association of School Business Officials
Virginia Association of School Business Officials
Council of Educational Facility Planners, International

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Linda K. Lemasters